Control	**0500-03-644, ETC.**
Project	**C 500-3-644, ETC.**
Highway	**IH 45, ETC.**
County	**HARRIS, ETC.**

ADDENDUM ACKNOWLEDGMENT

Each bidder is required to acknowledge receipt of an addendum issued for a specific project. This page is provided for the purpose of acknowledging an addendum.

FAILURE TO ACKNOWLEDGE RECEIPT OF AN ADDENDUM WILL RESULT IN THE BID NOT BEING READ.

In order to properly acknowledge an addendum place a mark in the box next to the respective addendum.

ADDENDUM NO. 1 ☐

ADDENDUM NO. 2 ☐

ADDENDUM NO. 3 ☐

ADDENDUM NO. 4 ☐

ADDENDUM NO. 5 ☐

In addition, the bidder by affixing their signature to the signature page of the proposal is acknowledging that they have taken the addendum(s) into consideration when preparing their bid and that the information contained in the addendum will be included in the contract, if awarded by the Commission or other designees.

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Control	**0500-03-644, ETC.**
Project	**C 500-3-644, ETC.**
Highway	**IH 45, ETC.**
County	**HARRIS, ETC.**

PROPOSAL TO THE TEXAS TRANSPORTATION COMMISSION

2014 SPECIFICATIONS

WORK CONSISTING OF DRAINAGE IMPROVEMENTS

HARRIS COUNTY, TEXAS, Etc.

The quantities in the proposal are approximate. The quantities of work and materials may be increased or decreased as considered necessary to complete the work as planned and contemplated.

This project is to be completed in 549 working days and will be accepted when fully completed and finished to the satisfaction of the Executive Director or designee.

Provide a proposal guaranty in the form of a Cashier's Check, Teller's Check (including an Official Check) or Bank Money Order on a State or National Bank or Savings and Loan Association, or State or Federally chartered Credit Union made payable to the Texas Transportation Commission in the following amount:

ONE HUNDRED THOUSAND (Dollars) **($100,000)**

A bid bond may be used as the required proposal guaranty. The bond form may be detached from the proposal for completion. The proposal may not be disassembled to remove the bond form. The bond must be in accordance with Item 2 of the specifications.

Any addenda issued amending this proposal and/or the plans that have been acknowledged by the bidder, become part of this proposal.

By signing the proposal the bidder certifies:

1. the only persons or parties interested in this proposal are those named and the bidder has not directly or indirectly participated in collusion, entered into an agreement or otherwise taken any action in restraint of free competitive bidding in connection with the above captioned project.
2. in the event of the award of a contract, the organization represented will secure bonds for the full amount of the contract.
3. the signatory represents and warrants that they are an authorized signatory for the organization for which the bid is submitted and they have full and complete authority to submit this bid on behalf of their firm.
4. that the certifications and representations contained in the proposal are true and accurate and the bidder intends the proposal to be taken as a genuine government record.

- **Signed: ****

(1) _____ (2) _____ (3) _____

Print Name:

(1) _____ (2) _____ (3) _____

Title:

(1) _____ (2) _____ (3) _____

Company:

(1) _____ (2) _____ (3) _____

- Signatures to comply with Item 2 of the specifications.

**Note: Complete (1) for single venture, through (2) for joint venture and through (3) for triple venture.

*** When the working days field contains an asterisk (*) refer to the Special Provisions and General Notes.**

NOTICE TO CONTRACTORS

ANY CONTRACTORS INTENDING TO BID ON ANY WORK TO BE AWARDED BY THIS DEPARTMENT MUST SUBMIT A SATISFACTORY "AUDITED FINANCIAL STATEMENT" AND "EXPERIENCE QUESTIONNAIRE" AT LEAST TEN DAYS PRIOR TO THE LETTING DATE.

UNIT PRICES MUST BE SUBMITTED IN ACCORDANCE WITH ITEM 2 OF THE STANDARD SPECIFICATIONS OR SPECIAL PROVISION TO ITEM 2 FOR EACH ITEM LISTED IN THIS PROPOSAL.

TEXAS DEPARTMENT OF TRANSPORTATION

BID BOND

KNOW ALL PERSONS BY THESE PRESENTS,

That we, (Contractor Name) _____

_____

Hereinafter called the Principal, and (Surety Name) _____

_____

a corporation or firm duly authorized to transact surety business in the State of Texas, hereinafter called the Surety, are held and firmly bound unto the Texas Department of Transportation, hereinafter called the Obligee, in the sum of not less than two percent (2%) of the department's engineer's estimate, rounded to the nearest one thousand dollars, not to exceed one hundred thousand dollars ($100,000) as a proposal guaranty (amount displayed on the cover of the proposal), the payment of which sum will and truly be made, the said Principal and the said Surety, bind ourselves, our heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

WHEREAS, the principal has submitted a bid for the following project identified as:

Control	**0500-03-644, ETC.**
Project	**C 500-3-644, ETC.**
Highway	**IH 45, ETC.**
County	**HARRIS, ETC.**

NOW, THEREFORE, if the Obligee shall award the Contract to the Principal and the Principal shall enter into the Contract in writing with the Obligee in accordance with the terms of such bid, then this bond shall be null and void. If in the event of failure of the Principal to execute such Contract in accordance with the terms of such bid, this bond shall become the property of the Obligee, without recourse of the Principal and/or Surety, not as a penalty but as liquidated damages.

Signed this _____ Day of _____ 20_____

By: _____

(Contractor/Principal Name)

_____

(Signature and Title of Authorized Signatory for Contractor/Principal)

*By: _____

(Surety Name)

_____

(Signature of Attorney-in-Fact)

*Attach Power of attorney (Surety) for Attorney-in-Fact

Impressed Surety Seal Only

This form may be removed from the proposal.

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BIDDER'S CHECK RETURN

IMPORTANT

The space provided for the return address must be completed to facilitate the return of your bidder's check. Care must be taken to provide a legible, accurate, and complete return address, including zip code. A copy of this sheet should be used for each different return address.

NOTE

Successful bidders will receive their guaranty checks with the executed contract.

RETURN BIDDERS CHECK TO (PLEASE PRINT):

Control	**0500-03-644, ETC.**
Project	**C 500-3-644, ETC.**
Highway	**IH 45, ETC.**
County	**HARRIS, ETC.**

IMPORTANT

PLEASE RETURN THIS SHEET IN ITS ENTIRETY

Please acknowledge receipt of this check(s) at your earliest convenience by signing below in longhand, in ink, and returning this acknowledgement in the enclosed self addressed envelope.

Check Received By: _____ Date:_____

Title: _____

For (Contractor's Name): _____

Project _____ County_____

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NOTICE TO THE BIDDER

In the space provided below, please enter your total bid amount for this project. Only this figure will be read publicly by the Department at the public bid opening.

It is understood and agreed by the bidder in signing this proposal that the total bid amount entered below is not binding on either the bidder or the Department. It is further agreed that **the official total bid amount for this proposal will be determined by multiplying the unit bid prices for each pay item by the respective estimated quantities shown in this proposal and then totaling all of the extended amounts.**

$_____

Total Bid Amount

Control 0001-03-030
Project STP 2000(938)HES
Highway SH 20
County EL PASO

ALT	ITEM	DESC	SP	Bid Item Description	Unit	Quantity	Bid Price	Amount	Seq
	104	509		REMOV CONC (SDWLK)	SY	266.400	$10.000	$2,664.00	1

EXAMPLE

Total Bid Amount _____$2,664.00_____

Signed _____
Title _____
Date _____

Additional Signature for Joint Venture:

Signed _____
Title _____
Date _____

EXAMPLE OF BID PRICES SUBMITTED BY COMPUTER PRINTOUT

EXAMPLES

BID PRICES SUBMITTED BY HAND WRITTEN FORMAT

ALT	ITEM-CODE			UNIT BID PRICE ONLY WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC NO	S.P. NO.				
	190	026		RED OAK 1 1/2 - 1 3/4 GAL BB	EA	9.000	1
				EXAMPLE: One hundred fifty DLRS and No CENTS			

Unit price for each plant in place

	249	014		FLEX BASE(DEL)(DENSCOT)(TY A GR4 CL2)	TON	56,787.00	14
				EXAMPLE: Seven DLRS and Fifty three CENTS			

Unit price for each ton of Flexible Base

	430	001	001	CL A CONC FOR EXT STR (CULV)	CY	45.000	27
				EXAMPLE: Three hundred five DLRS and No CENTS			

Unit price for each cubic yard of Concrete

	610	007	001	RDWY ILL ASSEM(TY ST 50T-8-8)(.4 KW)S	EA	13.000	7
				EXAMPLE: Fourteen hundred sixteen DLRS and Thirty seven CENTS			

Unit price of each Roadway Illumination Assembly

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ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	100	6001		PREPARING ROW DOLLARS and CENTS	AC	5.490	1
	100	6002		PREPARING ROW DOLLARS and CENTS	STA	25.000	2
	104	6009		REMOVING CONC (RIPRAP) DOLLARS and CENTS	SY	62.000	3
	104	6010		REMOVING CONC (RIPRAP) DOLLARS and CENTS	CY	96.000	4
	104	6015		REMOVING CONC (SIDEWALKS) DOLLARS and CENTS	SY	82.000	5
	104	6017		REMOVING CONC (DRIVEWAYS) DOLLARS and CENTS	SY	137.000	6
	104	6021		REMOVING CONC (CURB) DOLLARS and CENTS	LF	58.000	7
	105	6008		REMOVING STAB BASE AND ASPH PAV (6") DOLLARS and CENTS	SY	250.000	8
	110	6001		EXCAVATION (ROADWAY) DOLLARS and CENTS	CY	41.000	9
	110	6002		EXCAVATION (CHANNEL) DOLLARS and CENTS	CY	27,857.000	10
	132	6002	001	EMBANKMENT (FINAL)(DENS CONT)(TY A) DOLLARS and CENTS	CY	78.500	11
	132	6006	001	EMBANKMENT (FINAL)(DENS CONT)(TY C) DOLLARS and CENTS	CY	1,229.400	12

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	161	6017		COMPOST MANUF TOPSOIL (4") DOLLARS and CENTS	SY	10,536.000	13
	162	6002		BLOCK SODDING DOLLARS and CENTS	SY	34,632.000	14
	162	6003		STRAW OR HAY MULCH DOLLARS and CENTS	SY	19,335.000	15
	164	6009		BROADCAST SEED (TEMP) (WARM) DOLLARS and CENTS	SY	446.000	16
	164	6051		DRILL SEED (TEMP)(WARM OR COOL) DOLLARS and CENTS	SY	8,903.000	17
	164	6052		BROADCAST SEED (PERM)(SPECIAL MIX) DOLLARS and CENTS	SY	99.000	18
	164	6066		DRILL SEEDING (PERM)(WARM OR COOL) DOLLARS and CENTS	SY	9,888.000	19
	166	6001		FERTILIZER DOLLARS and CENTS	AC	11.200	20
	168	6001		VEGETATIVE WATERING DOLLARS and CENTS	MG	1,339.000	21
	360	6028	001	CONC PAV (JOINT REINF) (6") DOLLARS and CENTS	SY	529.000	22
	400	6005		CEM STABIL BKFL DOLLARS and CENTS	CY	2,273.400	23
	400	6006		CUT & RESTORING PAV DOLLARS and CENTS	SY	3,104.000	24

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	400	6009		CEMENT STAB BACKFILL (INLET OR MH) DOLLARS and CENTS	CY	547.800	25
	402	6001		TRENCH EXCAVATION PROTECTION DOLLARS and CENTS	LF	3,222.000	26
	403	6001		TEMPORARY SPL SHORING DOLLARS and CENTS	SF	16,578.000	27
	420	6143	001	CL S CONC (JUNCTION BOX) DOLLARS and CENTS	CY	60.500	28
	420	6153	001	CL A CONC (DITCH INTERCEPTOR STRUC-TURE) DOLLARS and CENTS	EA	2.000	29
	423	6005	007	RETAINING WALL (SPREAD FOOTING) DOLLARS and CENTS	SF	1,786.000	30
	432	6001		RIPRAP (CONC)(4 IN) DOLLARS and CENTS	CY	103.000	31
	432	6003		RIPRAP (CONC)(6 IN) DOLLARS and CENTS	CY	145.000	32
	432	6026		RIPRAP (STONE COMMON)(DRY)(18 IN) DOLLARS and CENTS	CY	8.700	33
	432	6045		RIPRAP (MOW STRIP)(4 IN) DOLLARS and CENTS	CY	1.300	34
	460	6003		CMP (GAL STL 24 IN) DOLLARS and CENTS	LF	173.000	35
	462	6001	002	CONC BOX CULV (3 FT X 2 FT) DOLLARS and CENTS	LF	21.000	36

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	462	6003	002	CONC BOX CULV (4 FT X 2 FT) DOLLARS and CENTS	LF	188.000	37
	462	6030	002	CONC BOX CULV (10 FT X 6 FT) DOLLARS and CENTS	LF	297.000	38
	464	6001	001	RC PIPE (CL III)(12 IN) DOLLARS and CENTS	LF	24.000	39
	464	6005	001	RC PIPE (CL III)(24 IN) DOLLARS and CENTS	LF	1,826.000	40
	464	6007	001	RC PIPE (CL III)(30 IN) DOLLARS and CENTS	LF	126.000	41
	464	6008	001	RC PIPE (CL III)(36 IN) DOLLARS and CENTS	LF	13.000	42
	464	6009	001	RC PIPE (CL III)(42 IN) DOLLARS and CENTS	LF	16.000	43
	464	6018	001	RC PIPE (CL IV)(24 IN) DOLLARS and CENTS	LF	147.000	44
	464	6019	001	RC PIPE (CL IV)(30 IN) DOLLARS and CENTS	LF	411.000	45
	464	6027	001	RC PIPE (CL V)(36 IN) DOLLARS and CENTS	LF	20.000	46
	464	6028	001	RC PIPE (CL V)(42 IN) DOLLARS and CENTS	LF	33.000	47
	465	6005	001	JCTBOX(COMPL)(PJB)(3FTX3FT) DOLLARS and CENTS	EA	4.000	48

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	465	6167	001	INLET (COMPL)(TY AD) DOLLARS and CENTS	EA	3.000	49
	465	6170	001	INLET (COMPL)(TY AZ) DOLLARS and CENTS	EA	1.000	50
	465	6173	001	MANH (COMPL)(TY A) DOLLARS and CENTS	EA	18.000	51
	465	6175	001	INLET (COMPL)(CURB)(TY C) DOLLARS and CENTS	EA	12.000	52
	465	6176	001	INLET (COMPL)(CURB)(TY C1) DOLLARS and CENTS	EA	8.000	53
	465	6196	001	INLET (COMPL)(TY A)(SPL) DOLLARS and CENTS	EA	1.000	54
	465	6278	001	INLET (COMPL)(TY B)(MOD) DOLLARS and CENTS	EA	1.000	55
	467	6110		SET (TY I)(S=3 FT)(HW= 3 FT)(6:1)(P) DOLLARS and CENTS	EA	2.000	56
	467	6139		SET (TY I)(S= 4 FT)(HW= 3 FT)(4:1) (C) DOLLARS and CENTS	EA	2.000	57
	467	6143		SET (TY I)(S= 4 FT)(HW= 4 FT)(3:1) (C) DOLLARS and CENTS	EA	2.000	58
	467	6323		SET (TY II) (12 IN) (RCP) (4: 1) (C) DOLLARS and CENTS	EA	2.000	59
	467	6377		SET (TY II) (24 IN) (CMP) (4: 1) (C) DOLLARS and CENTS	EA	1.000	60

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	467	6390		SET (TY II) (24 IN) (RCP) (4: 1) (C) DOLLARS and CENTS	EA	1.000	61
	467	6395		SET (TY II) (24 IN) (RCP) (6: 1) (P) DOLLARS and CENTS	EA	2.000	62
	467	6410		SET (TY II) (30 IN) (CMP) (6: 1) (P) DOLLARS and CENTS	EA	1.000	63
	476	6020		JACK BOR OR TUN PIPE(30 IN)(RC)(CL IV) DOLLARS and CENTS	LF	66.000	64
	496	6002		REMOV STR (INLET) DOLLARS and CENTS	EA	3.000	65
	496	6007		REMOV STR (PIPE) DOLLARS and CENTS	LF	223.000	66
	496	6048		REMOV STR (PUMP STA)(INTERN COMPO-NENTS) DOLLARS and CENTS	EA	3.000	67
	496	6049		REMOV STR (PUMP STA) (WALLS AND ROOF) DOLLARS and CENTS	EA	1.000	68
	500	6001		MOBILIZATION DOLLARS and CENTS	LS	1.000	69
	502	6001	008	BARRICADES, SIGNS AND TRAFFIC HAN-DLING DOLLARS and CENTS	MO	28.000	70
	506	6001	005	ROCK FILTER DAMS (INSTALL) (TY 1) DOLLARS and CENTS	LF	336.000	71

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	506	6011	005	ROCK FILTER DAMS (REMOVE) DOLLARS and CENTS	LF	336.000	72
	506	6020	005	CONSTRUCTION EXITS (INSTALL) (TY 1) DOLLARS and CENTS	SY	668.000	73
	506	6024	005	CONSTRUCTION EXITS (REMOVE) DOLLARS and CENTS	SY	668.000	74
	506	6038	005	TEMP SEDMT CONT FENCE (INSTALL) DOLLARS and CENTS	LF	3,420.000	75
	506	6039	005	TEMP SEDMT CONT FENCE (REMOVE) DOLLARS and CENTS	LF	3,420.000	76
	506	6040	005	BIODEG EROSN CONT LOGS (INSTL) (8") DOLLARS and CENTS	LF	463.000	77
	506	6041	005	BIODEG EROSN CONT LOGS (INSTL) (12") DOLLARS and CENTS	LF	251.000	78
	506	6043	005	BIODEG EROSN CONT LOGS (REMOVE) DOLLARS and CENTS	LF	714.000	79
	512	6021		PORT CTB (DES SOURCE)(LOW PROF)(TY 1) DOLLARS and CENTS	LF	4,900.000	80
	512	6022		PORT CTB (DES SOURCE)(LOW PROF)(TY 2) DOLLARS and CENTS	LF	380.000	81
	512	6033		PORT CTB (MOVE)(LOW PROF)(TY 1) DOLLARS and CENTS	LF	1,260.000	82
	512	6034		PORT CTB (MOVE)(LOW PROF)(TY 2) DOLLARS and CENTS	LF	140.000	83

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	512	6045		PORT CTB (STKPL)(LOW PROF)(TY 1) DOLLARS and CENTS	LF	2,560.000	84
	512	6046		PORT CTB (STKPL)(LOW PROF)(TY 2) DOLLARS and CENTS	LF	200.000	85
	512	6080		PORT CTB CONNECT HARDWARE DOLLARS and CENTS	EA	247.000	86
	529	6005		CONC CURB (MONO) (TY II) DOLLARS and CENTS	LF	280.000	87
	530	6004		DRIVEWAYS (CONC) DOLLARS and CENTS	SY	589.000	88
	530	6005		DRIVEWAYS (ACP) DOLLARS and CENTS	SY	250.000	89
	530	6025		DRIVEWAYS (CONC) (FAST TRACK) DOLLARS and CENTS	SY	55.000	90
	531	6003		CONC SIDEWALKS (6") DOLLARS and CENTS	SY	82.000	91
	540	6001	001	MTL W-BEAM GD FEN (TIM POST) DOLLARS and CENTS	LF	500.000	92
	540	6016	001	DOWNSTREAM ANCHOR TERMINAL SEC-TION DOLLARS and CENTS	EA	2.000	93
	540	6033	001	MTL BM GD FEN (LONG SPAN SYSTEM) DOLLARS and CENTS	EA	7.000	94
	542	6001		REMOVE METAL BEAM GUARD FENCE DOLLARS and CENTS	LF	833.000	95

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	544	6001		GUARDRAIL END TREATMENT (INSTALL) DOLLARS and CENTS	EA	2.000	96
	550	6001		CHAIN LINK FENCE (INSTALL) (6') DOLLARS and CENTS	LF	575.000	97
	550	6003		CHAIN LINK FENCE (REMOVE) DOLLARS and CENTS	LF	357.000	98
	550	6006		GATE (REMOVE) DOLLARS and CENTS	EA	2.000	99
	550	6030		CL FENCE GATE (INST)(DBL)(6')(BARB TOP) DOLLARS and CENTS	EA	1.000	100
	618	6046		CONDT (PVC) (SCH 80) (2") DOLLARS and CENTS	LF	550.000	101
	620	6009		ELEC CONDR (NO.6) BARE DOLLARS and CENTS	LF	400.000	102
	620	6010		ELEC CONDR (NO.6) INSULATED DOLLARS and CENTS	LF	800.000	103
	624	6001		GROUND BOX TY A (122311) DOLLARS and CENTS	EA	2.000	104
	624	6028		REMOVE GROUND BOX DOLLARS and CENTS	EA	2.000	105
	628	6002		REMOVE ELECTRICAL SERVICES DOLLARS and CENTS	EA	2.000	106
	628	6250		ELC SRV TY D 120/240 100(NS)SS(N)SP(O) DOLLARS and CENTS	EA	2.000	107

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	662	6064		WK ZN PAV MRK REMOV (W)6"(BRK) DOLLARS and CENTS	LF	3,025.000	108
	662	6067		WK ZN PAV MRK REMOV (W)6"(SLD) DOLLARS and CENTS	LF	5,766.000	109
	662	6098		WK ZN PAV MRK REMOV (Y)6"(SLD) DOLLARS and CENTS	LF	830.000	110
	666	6212	007	REFL PAV MRK TY II (Y) 12" (SLD) DOLLARS and CENTS	LF	6,244.000	111
	668	6115		PREFAB PAV MRK TY C (MULTI) (SHIELD) DOLLARS and CENTS	EA	1.000	112
	672	6010	001	REFL PAV MRKR TY II-C-R DOLLARS and CENTS	EA	182.000	113
	677	6001		ELIM EXT PAV MRK & MRKS (4") DOLLARS and CENTS	LF	8,025.000	114
	677	6002		ELIM EXT PAV MRK & MRKS (6") DOLLARS and CENTS	LF	20,331.000	115
	677	6003		ELIM EXT PAV MRK & MRKS (8") DOLLARS and CENTS	LF	3,880.000	116
	677	6005		ELIM EXT PAV MRK & MRKS (12") DOLLARS and CENTS	LF	7,104.000	117
	677	6007		ELIM EXT PAV MRK & MRKS (24") DOLLARS and CENTS	LF	468.000	118
	677	6008		ELIM EXT PAV MRK & MRKS (ARROW) DOLLARS and CENTS	EA	12.000	119

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	677	6012		ELIM EXT PAV MRK & MRKS (WORD) DOLLARS and CENTS	EA	14.000	120
	677	6022		ELIM EXT PAV MRK & MRKS (SHEILD) DOLLARS and CENTS	EA	1.000	121
	677	6036		ELIM EXT PAV MRK & MRKS (UTURN ARROW) DOLLARS and CENTS	EA	2.000	122
	678	6002		PAV SURF PREP FOR MRK (6") DOLLARS and CENTS	LF	20,331.000	123
	678	6004		PAV SURF PREP FOR MRK (8") DOLLARS and CENTS	LF	3,880.000	124
	678	6006		PAV SURF PREP FOR MRK (12") DOLLARS and CENTS	LF	7,104.000	125
	678	6008		PAV SURF PREP FOR MRK (24") DOLLARS and CENTS	LF	468.000	126
	678	6009		PAV SURF PREP FOR MRK (ARROW) DOLLARS and CENTS	EA	12.000	127
	678	6012		PAV SURF PREP FOR MRK (UTURN ARR) DOLLARS and CENTS	EA	2.000	128
	678	6016		PAV SURF PREP FOR MRK (WORD) DOLLARS and CENTS	EA	14.000	129
	678	6021		PAV SURF PREP FOR MRK (SYMBOL) DOLLARS and CENTS	EA	1.000	130
	4008	6001		TRENCH DRAIN DOLLARS and CENTS	LF	48.000	131

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	6001	6001		PORTABLE CHANGEABLE MESSAGE SIGN DOLLARS and CENTS	DAY	264.000	132
	6027	6003		CONDUIT (PREPARE) DOLLARS and CENTS	LF	150.000	133
	6038	6004		MULTIPOLYMER PAV MRK (W)(6")(SLD) DOLLARS and CENTS	LF	2,805.000	134
	6038	6005		MULTIPOLYMER PAV MRK (W)(6")(BRK) DOLLARS and CENTS	LF	5,371.000	135
	6038	6007		MULTIPOLYMER PAV MRK (W)(8")(SLD) DOLLARS and CENTS	LF	3,564.000	136
	6038	6011		MULTIPOLYMER PAV MRK (W)(12")(SLD) DOLLARS and CENTS	LF	860.000	137
	6038	6013		MULTIPOLYMER PAV MRK (W)(24")(SLD) DOLLARS and CENTS	LF	468.000	138
	6038	6017		MULTIPOLYMER PAV MRK (Y)(6")(SLD) DOLLARS and CENTS	LF	7,834.000	139
	6038	6018		MULTIPOLYMER PAV MRK (Y)(6")(BRK) DOLLARS and CENTS	LF	430.000	140
	6038	6020		MULTIPOLYMER PAV MRK (Y)(8")(SLD) DOLLARS and CENTS	LF	316.000	141
	6038	6024		MULTIPOLYMER PAV MRK (BLK)(6")(BRK) DOLLARS and CENTS	LF	5,191.000	142
	6038	6025		MULTIYPOLYMER PAV MRK (W) (ARROW) DOLLARS and CENTS	EA	12.000	143

ALT	ITEM-CODE			UNIT BID PRICE ONLY. WRITTEN IN WORDS	UNIT	APPROX QUANTITIES	DEPT USE ONLY
	ITEM NO	DESC CODE	S.P. NO.				
	6038	6027		MULTIPOLYMER PAV MRK (W) (WORD) DOLLARS and CENTS	EA	14.000	144
	6038	6029		MULTIPOLYMER PAV MRK (W)(U-TURN ARROW) DOLLARS and CENTS	EA	2.000	145
	6185	6002	002	TMA (STATIONARY) DOLLARS and CENTS	DAY	264.000	146
	6185	6003	002	TMA (MOBILE OPERATION) DOLLARS and CENTS	HR	2,112.000	147
	7361	6001		AUTOMATIC PUMPING STATION - SL 8 DOLLARS and CENTS	EA	1.000	148
	7363	6001		AUTOMATIC PUMPING STATION - IH 45 DOLLARS and CENTS	EA	1.000	149
	7364	6001		AUTOMATIC PUMPING STATION - SH 6 DOLLARS and CENTS	EA	1.000	150

CERTIFICATION OF INTEREST IN OTHER BID PROPOSALS FOR THIS WORK

By signing this proposal, the bidding firm and the signer certify that the following information, as indicated by checking “Yes” or “No” below, is true, accurate, and complete.

A. Quotation(s) have been issued in this firm's name to other firm(s) interested in this work for consideration for performing a portion of this work.

_____ YES

_____ NO

B. If this proposal is the low bid, the bidder agrees to provide the following information prior to award of the contract.

1. Identify firms which bid as a prime contractor and from which the bidder received quotations for work on this project.
2. Identify all the firms which bid as a prime contractor to which the bidder gave quotations for work on this project.

ENGINEER SEAL

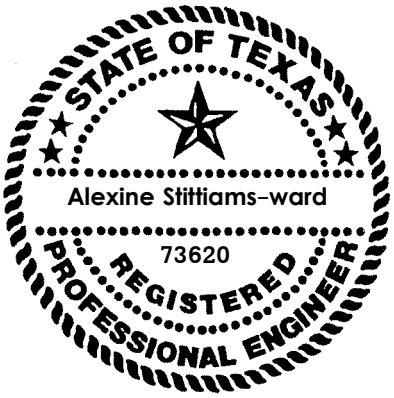
Control **0500-03-644, ETC.**

Project **C 500-3-644, ETC.**

Highway **IH 45, ETC.**

County **HARRIS, ETC.**

The enclosed Texas Department of Transportation Specifications, Special Specifications, Special Provisions, General Notes and Specification Data in this document have been selected by me, or under my responsible supervision as being applicable to this project. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act.



The seal appearing on this document was authorized by

Alexine Stittiams-ward, P.E.

MAY 31, 2024

County: HARRIS, Etc. **Control:** 0500-03-644, Etc.

Highway: IH 45, Etc.

General:

Area Engineer contact information for this project follows:

Jamal M. Elahi, PE., *Phone: (281) 464-5501,* *Email: Jamal.Elahi@txdot.gov*
Vanessa Bosques, PE., *Phone: (281) 464-5503,* *Email: Vanessa.Bosques@txdot.gov*

Submit any questions about this project via the "Letting Pre-Bid Q&A" web page, located at:

https://tableau.txdot.gov/views/ProjectInformationDashboard/NoticetoContractors

The "Letting Pre-Bid Q&A" web page for each project can be accessed by scrolling or filtering the dashboard using the controls on the left side to navigate to the project. Hover over the blue hyperlink of the project to view the Q&A and click on the link in the window that pops up.

Large files with relevant project documentation, such as geotechnical reports, as-built plans, and cross-sections will continue to be provided on the following FTP site:

https://ftp.dot.state.tx.us/pub/txdot-info/Pre-Letting%20Responses/Houston%20District/

If fixed features require, the governing slopes shown may vary between the limits shown and to the extent determined by the Engineer.

Superelevate the curves to match the existing surface.

Notify the Engineer immediately if discrepancies are discovered in the horizontal control or the benchmark data.

References to manufacturer's trade name or catalog numbers are for the purpose of identification only. Similar materials from other manufacturers are permitted if they are of equal quality, comply with the specifications for this project, and are approved, except for roadway illumination, electrical, and traffic signal items.

The cost for materials, labor, and incidentals to provide for traffic across the roadway and for ingress and egress to private property in accordance with Section 7.2.4 of the standard specifications is subsidiary to the various bid items. Restore access roadways to their original condition upon completing construction.

Grade street intersections and median openings for surface drainage.

If a foundation is to be placed where a riprap surface or an asphalt concrete surface presently exists, use caution in breaking out the existing surface for placement. Break out no greater area than is required to place the foundation. After placing the foundation, wrap the periphery with 0.5 in. pre-molded mastic expansion joint. Then replace the remaining portion of the broken-out surface with Class A or Class C concrete or cold mix asphalt concrete to the exact slope, pattern,

and thickness of the existing riprap or asphalt. Payment for breaking out the existing surface, wrapping the foundation, and replacing the surface is subsidiary to the various bid items.

The lengths of the posts for ground mounted signs and the tower legs for the overhead sign supports are approximate. Verify the lengths before ordering these materials to meet the existing field conditions and to conform to the minimum sign mounting heights shown in the plans.

Furnish aluminum Type A signs instead of plywood signs for signs shown on the Summary of Small Signs sheet.

Stencil the National Bridge Inventory (NBI) number on each existing bridge shown on these plans. The NBI number is shown above the title block for each bridge layout.

Clearly mark or highlight on the shop drawings, the items being furnished for this project. Submit required shop drawings in accordance with the shop drawing distribution list shown in the note for Item 5 for review and distribution.

Right of way parcels or utility adjustments shown to be unclear on the plans but not listed on the special provisions will have no effect on construction.

Make requests for additional soil information for this project at the Area Engineer's office.

Any groundwater elevation information provided is representative of conditions existing on the day when and for the specific location where this information was collected. The actual groundwater elevation may fluctuate with time, climatic conditions, and construction activity.

General: Roadway Illumination and Electrical

For roadway illumination and electrical items, use materials from pre-qualified producers as shown on the Construction Division (CST) of the Department's material producers list. Check the latest link on the Department's website for this list. The category/item is "Roadway Illumination and Electrical Supplies." No substitutions will be allowed for materials found on this list.

Perform electrical work in conformance with the National Electrical Code (NEC) and the Department's standard sheets.

General: Traffic Signals

For traffic signal items, use materials from the Pre-Qualified Producers List (located at http://www.dot.state.tx.us/GSD/purchasing/supps.htm) and the materials pre-qualified for illumination and electrical items (located at https://ftp.dot.state.tx.us/pub/txdot-info/cmd/mpl/archive/) as shown on the Department's Material Producers List and the Roadway Illumination and Electrical Supplies List. Check the latest links on the Department's website for these lists. No substitutions will be allowed for materials found on these lists.

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Highway: IH 45, Etc.

General: Site Management

Mow the grass and weeds within the project limits a maximum of 3 times a year as directed. This work is subsidiary to the various bid items.

Mark stations every 100 ft. and maintain the markings for the project duration. Remove the station markings at the completion of the project. This work is subsidiary to the various bid items.

Do not mix or store materials, or store or repair equipment, on top of concrete pavement or bridge decks unless authorized by the Engineer. Permission will be granted to store materials on surfaces if no damage or discoloration will result.

Personal vehicles of employees are not permitted to park within the right of way, including sections closed to public traffic. Employees may park on the right of way at the Contractor's office, equipment, and materials storage yard sites.

Assume ownership of debris and dispose of at an approved location. Do not dispose of debris on private property unless approved in writing by the District Engineer.

Control the dust caused by construction operations. For sweeping the base material in preparation for laying asphalt and for sweeping the finished concrete pavement, use one of the following types of sweepers or approved equal:

Tricycle Type	**Truck Type - 4 Wheel**
Wayne Series 900	M-B Cruiser II
Elgin White Wing	Wayne Model 945
Elgin Pelican	Mobile TE-3
	Mobile TE-4
	Murphy 4042

General: Traffic Control and Construction

Schedule construction operations such that preparing individual items of work follows in close sequence to constructing storm drains in order to provide as little inconvenience as practical to the businesses and residents along the project.

Schedule work so that the base placement operations follow the subgrade work as closely as practical to reduce the hazard to the traveling public and to prevent undue delay caused by wet weather.

This project requires extensive grading operations in an environmentally sensitive area.

County: HARRIS, Etc. **Control:** 0500-03-644, Etc.

Highway: IH 45, Etc.

If fences cross construction easements shown on the plans and work is required beyond the fences, remove and replace the fences as directed. This work and the materials are subsidiary to the various bid items.

When design details are not shown on the plans, provide signs and arrows conforming to the latest "Standard Highway Sign Designs for Texas" manual.

General: Utilities

Consider the locations of underground utilities depicted in the plans as approximate and employ responsible care to avoid damaging utility facilities. Depending upon scope and magnitude of planned construction activities, advanced field confirmation by the utility owner or operator may be prudent. Where possible, protect and preserve permanent signs, markers, and designations of underground facilities.

If the Contractor damages or causes damage (breaks, leaks, nicks, dents, gouges, etc.) to the utility, contact the utility facility owner or operator immediately.

Be aware that an operational Computerized Transportation Management System (CTMS) exists within the limits of this project and that the system must remain operational throughout construction. If the Contractor damages or causes damage to this system, repair such damage within 8 hours of occurrence at no cost to the Department. In the event of system damage, notify the Director of Traffic Management Systems at 713-881-3283 within one hour of occurrence. Failure of the Contractor to repair damage to the main fiber optic cable and CCTV cable trunk lines, which convey all corridor information to TranStar, will result in the Contractor being billed for the full cost of emergency repairs.

At least 72 hours before starting work, make arrangements for locating existing Department-owned above ground and underground fiber optic, communications, power, illumination, and traffic signal cabling and conduit. Do this by calling the Department's Houston District Traffic Signal Operations Office at 713-802-5662, or by e-mailing the Department's Houston District Traffic Signal Operations Office at: HOU-LocateRequest@txdot.gov, to schedule marking of underground lines on the ground. Use caution if working in these areas to avoid damaging or interfering with existing facilities.

Notify the Engineer at least 48 hours before constructing junction boxes at storm drain and utility intersections.

Install or remove poles and luminaires located near overhead or underground electrical lines using established industry and utility safety practices. Consult the appropriate utility company before beginning such work.

If overhead or underground power lines need to be de-energized, contact the electrical service provider to perform this work. Costs associated with de-energizing the power lines or other protective measures required are at no expense to the Department.

If working near power lines, comply with the appropriate sections of Texas State Law and Federal Regulations relating to the type of work involved.

Perform electrical work in conformance with the National Electrical Code (NEC) and Department's standard sheets.

Before beginning any underground work, notify the City of Houston's Chief Inspector, Public Works and Engineering, to establish the locations of any existing electrical systems for lighting facilities within the limits of this project.

Item 5: Control of Work

Before contract letting, cross-section data for this project will be available to the prospective bidders in PDF format on the Department's Houston District website located at:

https://ftp.dot.state.tx.us/pub/txdot-info/Pre-Letting%20Responses/Houston%20District/Construction%20Projects/

The cross-section data provided above is for non-construction purposes only and it is the responsibility of the prospective bidder to validate the data with the appropriate plans, specifications, and estimates for the projects.

Submit shop drawings electronically for the fabrication of items as documented in Table 1 or Table 2 below. Information and requirements for electronic submittals can be viewed in the "Guide to Electronic Shop Drawing Submittal" which can be accessed through the following web link, https://ftp.txdot.gov/pub/txdot-info/library/pubs/bus/bridge/e_submit_guide.pdf References to 11 in. x 17 in. sheets in individual specifications for structural items imply electronic CAD sheets.

Table 1

Construction Specification Required Shop/Working Drawing Submittals - TxDOT Generated Plans

Spec Item No.'s	Product	Submittal Required	Approval Required (Y/N)	Contractor/ Fabricator P.E. Seal Required	Reviewing Party	Shop or Working Drawing (Note 1)
7.16.1&.2	Construction Load Analyses	Y	Y	Y	B	WD
400	Excavation and Backfill for Structures (cofferdams)	Y	N	Y	A	WD
403	Temporary Special Shoring	Y	N	Y	C	WD
420	Formwork/Falsework	Y	N	Y	A	WD
423	Retaining Walls, (calcs req'd.)	Y	Y	Y	C	SD
425	Optional Design Calculations (Prstrs Bms)	Y	Y	Y	B	SD

425	Prestr Concr Sheet Piling	Y	Y	N	B	SD
425	Prestr Concr Beams	Y	Y	N	B	SD
425	Prestr Concr Bent	Y	Y	N	B	SD
426	Post Tension Details	Y	Y	N	B	SD
434	Elastomeric Bearing Pads (All)	Y	Y	N	B	SD
441	Bridge Protective Assembly	Y	Y	N	B	SD
441	Misc Steel (various steel assemblies)	Y	Y	N	B	SD
441	Steel Pedestals (bridge raising)	Y	Y	N	B	SD
441	Steel Bearings	Y	Y	N	B	SD
441	Steel Bent	Y	Y	N	B	SD
441	Steel Diaphragms	Y	Y	N	B	SD
441	Steel Finger Joint	Y	Y	N	B	SD
441	Steel Plate Girder	Y	Y	N	B	SD
441	Steel Tub-Girders	Y	Y	N	B	SD
441	Erection Plans, including Falsework	Y	N	Y	A	WD
449	Sign Structure Anchor Bolts	Y	Y	N	T	SD
450	Railing	Y	Y	N	A	SD
462	Concrete Box Culvert	Y	Y	N	C	SD
462	Concrete Box Culvert (Alternate Designs Only,calcs reqd.)	Y	Y	Y	B	SD
464	Reinforced Concrete Pipe (Jack and Bore only; ONLY when requested)	Y	Y	Y	A	SD
465	Pre-cast Junction Boxes, Grates, and Inlets	Y	Y	N	A	SD
465	Pre-cast Junction Boxes, Grates, and Inlets (Alternate Designs Only, calcs req'd.)	Y	Y	Y	B	SD
466	Pre-cast Headwalls and Wingwalls	Y	Y	N	A	SD
467	Pre-cast Safety End Treatments	Y	Y	N	A	SD
495	Raising Existing Structure (calcs reqd.)	Y	Y	Y	B	SD
610	Roadway Illumination Supports (Non-Standard only, calcs reqd.)	Y	Y	Y	BRG	SD
613	High Mast Illumination Poles (Non-standard only, calcs reqd.)	Y	Y	Y	BRG	SD
627	Treated Timber Poles	Y	Y	N	T	SD
644	Special Non-Standard Supports (Bridge Mounts, Barrier Mounts, Etc.)	Y	Y	Y	T	SD
647	Large Roadside Sign Supports	Y	Y	Y	T	SD
650	Cantilever Sign Structure Supports - Alternate Design Calcs.	Y	Y	Y	T	SD
650	Sign Structures	Y	Y	N	T	SD
680	Installation of Highway Traffic Signals	Y	Y	N	T	SD
682	Vehicle and Pedestrian Signal Heads	Y	Y	N	T	SD
684	Traffic Signal Cables	Y	Y	N	T	SD
685	Roadside Flashing Beacon Assemblies	Y	Y	N	T	SD
686	Traffic Signal Pole Assemblies (Steel) (Non-Standard only)	Y	Y	Y	T	SD

687	Pedestal Pole Assemblies	Y	Y	N	T	SD
688	Detectors	Y	Y	N	A	SD
784	Repairing Steel Bridge Members	Y	Y	Y	B	WD
SS	Prestr Concr Crown Span	Y	Y	N	B	SD
SS	Sound Barrier Walls	Y	Y	Y	A	SD
SS	Camera Poles	Y	Y	Y	TMS	SD
SS	Pedestrian Bridge (Calcs req'd.)	Y	Y	Y	B	SD
SS	Screw-In Type Anchor Foundations	Y	Y	N	T	SD
SS	Fiber Optic/Communication Cable	Y	Y	N	TMS	SD
SS	Spread Spectrum Radios for Signals	Y	Y	N	T	SD
SS	VIVDS System for Signals	Y	Y	N	T	SD
SS	CTMS Equipment	Y	Y	N	TMS	SD

Notes:

1. Document flow for Working Drawings differs from Shop Drawings in that Working Drawings must be submitted to the Engineer rather than the Engineer of Record and they are for the information of the Engineer only; an approval stamp and distribution to all project offices is not required.

Key to Reviewing Party

A - Area Office

Area Office	Email Address
Southeast Area Office	HOU-SEHAShpDrwgs@txdot.gov

B - Houston Bridge Engineer

Bridge Design (Houston TxDOT)	HOU-BrgShpDrwgs@txdot.gov

BRG - Austin Bridge Division

Bridge Design (Austin TxDOT)	BRG_ShopPlanReview@txdot.gov

C - Construction Office

Construction	HOU-ConstrShpDrwgs@txdot.gov
Laboratory	HOU-LabShpDrwgs@txdot.gov

T - Traffic Engineer

Traffic Operations	HOU-TrfShpDrwgs@txdot.gov

TMS – Traffic Management System

Computerized Traffic Management Systems (CTMS)	HOU-CTMSShpDrwgs@txdot.gov

When a precast or cast-in-place concrete element is included in the plans, a precast concrete alternate may be submitted in accordance with "Standard Operating Procedure for Alternate Precast Proposal Submission" found online at https://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/publications/bridge.html#design. Acceptance or denial of an alternate is at the sole discretion of the Engineer. Impacts to the project schedule and any additional costs resulting from the use of alternates are the sole responsibility of the Contractor.

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Item 7: Legal Relations and Responsibilities

Do not initiate activities in a Project Specific Location (PSL), associated with a U.S. Army Corps of Engineers (USACE) permit area, that have not been previously evaluated by the USACE as part of the permit review of this project. Such activities include those pertaining to, but are not limited to, haul roads, equipment staging areas, borrow and disposal sites. Associated defined here means materials are delivered to or from the PSL. The permit area includes the waters of the U.S. or associated wetlands affected by activities associated with this project. Special restrictions may be required for such work. Assume responsibility for consultations with the USACE regarding activities, including PSLs that have not been previously evaluated by the USACE. Provide the Department with a copy of consultations or approvals from the USACE before initiating activities.

The Contractor may proceed with activities in PSLs that do not affect a USACE permit area if a self-determination has been made that the PSL is non-jurisdictional or if proper USACE clearances have been obtained in jurisdictional areas or have been previously evaluated by the USACE as part of the permit review of this project. The Contractor is solely responsible for documenting any determinations that their activities do not affect a USACE permit area. Maintain copies of their determinations for review by the Department or any regulatory agency.

Document and coordinate with the USACE, if required, before hauling any excavation from or hauling any embankment to a USACE permit area by either 1 or 2 below:

1. **Restricted Use of Materials for the Previously Evaluated Permit Areas.** Document both the Project Specific Locations (PSL) and their authorization. Maintain copies for review by the Department or any regulatory agency. When an area within the project limits has been evaluated by the USACE as part of the permit process for this project:
   a. Suitable excavation of required material in the areas shown on the plans and cross sections as specified in the Item, “Excavation” is used for permanent or temporary fill (under the Item, “Embankment”) within a USACE permit area.
   b. Suitable embankment (under the Item, “Embankment”) from within the USACE permit area is used as fill within a USACE evaluated area.
   c. Unsuitable excavation or excess excavation, “Waste” (under the Item, “Excavation”), that is disposed of at a location approved within a USACE evaluated area.

2. **Contractor Materials from Areas Other than Previously Evaluated Areas.** Provide the Department with a copy of USACE coordination or approvals before initiating any activities for an area within the project limits that has not been evaluated by the USACE or for any off right of way locations used for the following, but not limited to, haul roads, equipment staging areas, borrow and disposal sites:

a. The Item, "Embankment" used for temporary or permanent fill within a USACE permit area.
b. Unsuitable excavation or excess excavation, "Waste" (under the Item, "Excavation"), that is disposed of outside a USACE evaluated area.

The total area disturbed for this project is 0.48 acres for IH 45, 3.34 acres for SL 8, and 3.46 acres for SH 6. The disturbed area in this project, the project locations in the contract, and Contractor project specific locations (PSLs) within 1 mile of the project limits for the contract, will further establish the authorization requirements for storm water discharges. The Department will obtain an authorization to discharge storm water from the Texas Commission on Environmental Quality (TCEQ) for the construction activities shown on the plans. The Contractor is to obtain required authorization from the TCEQ for Contractor PSLs for construction support activities on or off the ROW. When the total area disturbed in the contract and PSLs within 1 mile of the project limits exceeds 5 acres, provide a copy of the Contractor NOI for PSLs on the ROW to the Engineer (to the appropriate MS4 operator when on an off-state system route) and to the local government that operates a separate storm drain system.

This project does not require a U.S. Army Corps of Engineers (USACE) Section 404 Permit before letting, but if a permit is needed during construction, assume responsibility for preparing the permit application. Submit the permit application to the Department's District Environmental Section for approval. Once the permit application is approved, the Department will submit it to the USACE. Assume responsibility for the requested revisions, in coordination with the Department's District Environmental Section.

Do not store any material in Waters of the United States inside the right of way without written approval.

Before construction operations begin, provide a drawing of the location of proposed temporary access roads, haul roads, or temporary fill used during construction operations to ensure that they are not within Jurisdictional Waters of the United States.

If the Contractor elects to use an area not permitted and determined to be within Jurisdictional Waters of the United States during the prosecution of the work, the Contractor will hold the Department harmless for delays caused by procuring the necessary permits from the United States Army Corps of Engineers.

Maintain the roadway slope stability. Maintaining slope stability is subsidiary to the various bid items.

If the work is on or in the vicinity of an at-grade railroad crossing, involves incidental work on railroad right of way, or involves construction of a railroad grade separation structure, notify the railroad company's Division Engineer and the Department's Project Engineer at least 30 days before performing any work on the railroad right of way and make arrangements for railroad flaggers unless otherwise shown in the contract. Obtain the required Railroad Right of Entry Permit from the railroad company. Payment of applicable permit fees is the responsibility of the

County: HARRIS, Etc. **Control:** 0500-03-644, Etc.

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Contractor. Acquiring the Railroad Right of Entry Permit is a lengthy process, allow sufficient time for this.

The nesting / breeding season for migratory birds is February 15 through September 30.

Conduct any tree removal outside of the migratory bird nesting season. If this is not possible due to scheduling, then exercise caution to remove only those trees with no active nests. Do not destroy nests on structures or in trees within the project limits during the nesting / breeding season.

Take measures to prevent the building of nests on any structures or trees within the project limits throughout the duration of the construction if work / removal will be performed during the nesting / breeding season. This can be accomplished by application of bird repellent gel, netting by hand every 3 to 4 days, or any other non-threatening method approved by the Houston District Environmental Section. Obtain this approval well in advance of the planned use. Contact the Houston District Environmental Section at 713-802-5244. The cost of this work is subsidiary to the various bid items.

This project is on a hurricane evacuation route. Provide at the pre-construction meeting a written plan outlining procedures to suspend work, secure the job site, and safely handle traffic through and across the project in the event of a hurricane evacuation.

During the hurricane season (June 1 through November 30), do not close any travel lanes except when the Contractor can demonstrate that he/she can provide labor, equipment, material, a work plan, and quality of work to satisfactorily return all lanes to an open, all-weather travel surface within 3 days of receiving written or verbal notice but no later than 3 days before the predicted hurricane landfall. Construction of temporary lanes to an all-weather surface will be paid for in accordance with Article 9.7, "Payment for Extra Work and Force Account Method."

In addition to lane closures, cease work 3 days before the predicted hurricane landfall on or near the roadway that adversely impacts the flow of traffic and reduces the capacity of the highway during an evacuation. Vehicles of the Contractor, subcontractors, or material suppliers will not be allowed to enter or exit the traffic stream, including those for the purpose of material hauling and delivery, and mobilization or demobilization of equipment. When directed, this prohibition will include a reasonable time period for the evacuees to return to their point of origin.

No significant traffic generator events have been identified.

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Item 8: Prosecution and Progress

The Department will not adjust the number of days for the project and milestones, if any, due to differences in opinion regarding any assumptions made in the preparation of the schedule or for errors, omissions, or discrepancies found in the time determination schedule.

Working days will be computed and charged based on a Five-Day workweek in accordance with Section 8.3.1.1.

Provide a virus-free computer disk or other acceptable electronic media containing the Primavera construction schedule.

The maximum number of days the time charges on this contract may be suspended due to contractor mobilization, and material fabrication/accumulation or processing delays is 60 days. The Engineer and the Contractor may mutually agree, in writing, to decrease this maximum number of days.

The Lane Closure Assessment Fee is $500/lane-hour for IH 45, $500/lane-hour for SL 8, and $500/lane-hour for SH 6. This fee applies to the Contractor for closures or obstructions that overlap into restricted hour traffic for each hour or portion thereof, per lane, regardless of the length of lane closure or obstruction. For Restricted Hours subject to Lane Assessment Fee refer to the Item, "Barricades, Signs, and Traffic Handling." The time increment for the Lane Closure Assessment fee for this project is one hour.

Item 100: Preparing Right of Way

Obtain a City of Houston plumbing permit and a demolishing permit or removing permit before demolishing or removing existing houses or commercial buildings.

Clean existing ditches under fill sections of undesirable materials including grass, muck, and trash. Perform this work in accordance with the Construction section of the Item, "Preparing Right of Way." This work is subsidiary to this bid Item.

The Item, "Preparing Right of Way" will be measured for payment only in those designated areas shown on the plans. Preparing right of way necessary to perform construction that is outside designated areas is subsidiary to this bid Item.

Remove abandoned utilities that are in conflict with the new utilities, at no expense to the Department.

Reestablish and maintain right of way stakes after completing the right of way preparation activities and until the new utilities are in place.

Remove and assume ownership of the existing ground mounted signs within the limits of roadway construction unless otherwise noted or directed. This work is subsidiary to the Item, "Preparing Right of Way."

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Item 104: Removing Concrete

Removing concrete curb is paid as a separate bid item if the existing pavement on which it rests is not removed at the same time.

Item 105: Removing Treated and Untreated Base and Asphalt Pavement

Removing curb on cement-treated and untreated base or on cement treatment being removed at the same time is subsidiary to this bid Item.

Item 104: Removing Concrete
Item 105: Removing Treated and Untreated Base and Asphalt Pavement
Item 305: Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement

Case 5 - Concrete pavement over base

Removing the concrete pavement material is paid under the Item, "Removing Concrete."

Removing the base material and any asphalt bondbreaker material is paid under the Item, "Removing Treated and Untreated Base and Asphalt Pavement."

Item 110: Excavation

If manipulating the excavated material requires moving the same material more than once to accomplish the desired results, the excavation is measured and paid for only once regardless of the manipulation required.

Transition the ditch grades and channel bottom widths at structure locations. Use only approved channel excavation in the embankment.

The total excavation quantity shown on the plans includes the quantity for excavating to 2 ft. behind the back of the proposed curb.

Item 132: Embankment

If salvaged base is used for the embankment material, break it into small pieces to achieve the required density and to facilitate placing in the embankment. Obtain approval of the material before placing in the embankment.

Furnish Type C material with a maximum Liquid Limit (LL) of 65, a minimum Plasticity Index (PI) of 5, and composed of suitable earth material such as loam, clay, or other materials that form a suitable embankment.

The embankment material used on the project which has a Liquid Limit exceeding 45 will be tested for Liquid Limits at the rate of one test per 20,000 cu. yd. or per total quantity less than 20,000 cu. yd., unless otherwise directed. Only use material that passes the above tests.

For unpaved areas, provide a finished grade with the top 4 in. capable of sustaining vegetation. Use fertile soil that is easily cultivated, free from objectionable material and highly resistant to erosion. Topsoil work is paid under the Item, "Topsoil."

Furnish material with a maximum Liquid Limit (LL) of 65.

Item 161: Compost
Item 162: Sodding for Erosion Control
Item 164: Seeding for Erosion Control
Item 166: Fertilizer
Item 168: Vegetative Watering

Refer to the "Fertilizer, Seed, Sod, Straw, Compost, and Water" plan sheet for material specifications, application rates, and for watering requirements.

Item 204: Sprinkling

Perform subsidiary sprinkling as required under various other items in accordance with the Item, "Sprinkling."

Sprinkling for dust control is subsidiary to the various bid items.

Item 260: Lime Treatment (Road-Mixed)

For slurry placing, before discharging through the distributors, sufficiently agitate or mix the lime and water to place the lime in suspension and to obtain a uniform mixture.

The Engineer will observe the lime treatment that the Contractor elects to open to construction traffic immediately after compaction. If the construction traffic damages the subgrade, route the traffic off the damaged section in accordance with the standard specification. If the construction traffic does not damage the subgrade, cure the subgrade until other courses of material cover it. Apply these courses within 14 days with a maximum curing period of 7 days.

Place the hydrated and the commercial lime as a water suspension or slurry according to the slurry placing method shown in Section 260.4.3.2, "Slurry Placement."

Use the type of lime at particular locations as directed.

Place the quicklime dry or as a slurry.

For the dry quicklime, a spreader box is not required if the lime material is evenly distributed.

In limited areas, the Contractor may construct the lime slurry subgrade under a sequence of work in which the application, mixing, and compaction are completed in the same working day, if approved by the Engineer.

Provide documentation from certified public scales showing gross, tare, and net weights. Provide producer's delivery tickets also showing gross, tare, and net weights. Completely empty the lime trailers at the project site. The Engineer may direct the Contractor to reweigh any shipment of lime on certified scales. The cost of this operation is subsidiary to the Item, "Lime Treatment (Road-Mixed)."

The percentage of lime shown on the plans is estimated on the basis of engineering tests. If soil tests made during construction indicate properties different than those originally anticipated, the Engineer may vary the percentage of the lime to provide soil characteristics similar to those of the preliminary tests.

Mix the lime with the new base material in an approved pug mill type stationary mixer.

Item 360: Concrete Pavement

Where the pavement curb is left off for a later tie, provide the dowels or the tie bars as indicated on the paving detail sheets. The dowel bars and tie bars are subsidiary to the various bid items.

Repair portions of the concrete pavement surfaces that are damaged while in a plastic state before that area receives permanent pavement markings and opens to traffic. Perform repairs that are structurally equivalent to and cosmetically uniform with the adjacent undamaged areas. Do not repair by grouting onto the surface.

On pavement widening, hand finishing in place of the longitudinal float will be permitted.

Where existing pavement is widened with new pavement, place the new pavement a minimum of 2 ft. wide.

Equip the batching plants to proportion by weight, aggregates, and bulk cement, using approved proportioning devices and approved automatic scales.

For mono curb, the curb height transitions will be paid at the contract unit price of the larger curb height in the transition. The 2.5-in. laydown curbs for driveways will be paid at the unit price bid for the Item, "Conc Curb (Mono) (Ty II)."

High-early strength cement may be used for frontage road and city street intersection construction.

Do not use limestone dust of fracture as fine aggregate.

If the concrete design requires greater than 5.5 sacks of cementitious material per cubic yard, obtain written approval. If placing concrete pavement mixes from April 1 to October 31, inclusive, use Mix Design Option 1 as specified in Section 421.4.2.6.1.

Perform saw cutting as shown on the plans in accordance with Section 360.4.10, "Sawing Joints." This saw cutting is subsidiary to this bid Item.

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Complete the entire Fast Track concrete construction process, from the time the Fast Track Work Area is closed to traffic, to the time the Fast Track Work Area is opened to traffic. The Fast Track operation includes, but is not limited to, traffic control, existing pavement and subgrade removal, preparation of subgrade, placement of steel, placement of Fast Track concrete pavement, cure time, striping, etc. Perform work in the Fast Track Work Area in an expeditious manner, within the allowable time period for any area shown below:

Fast Track Work Area	Allowable Duration
1. IH 45 Westbound Frtg Rd. Sta 12+96.72 to Sta 28+10.50	7 week-days maximum
2. SH 6 Eastbound Sta 14+00.00 to Sta 19+20.00	7 week-days maximum
3. SH 6 Westbound Sta 14+00.00 to Sta 19+20.00	7 week-days maximum

Failure to perform any Fast Track Work Area construction within the above time frames will be cause for the Engineer to require the Contractor to shut down all other construction operations to ensure all resources are directed toward the completion of the Fast Track operation. This shutdown will remain in force until the Fast Track operation is complete. Such a shutdown will not warrant additional time, time suspension, or any additional costs to the Department.

Unless otherwise directed in writing, provide High Early Strength (Class HES) concrete with a minimum average flexural strength of 425 psi or a minimum average compressive strength of 3,000 psi in 16 hours.

When directed in writing, open the pavement to traffic before the minimum requirements have been attained.

When needed, place and remove forms in accordance with Section 360.4.5, except do not remove forms until at least 6 hours after concrete has been placed. The time for the form removal may be extended with the direction of the Engineer if weather or other conditions make it advisable.

Sprinkling and rolling, required for the compaction of the rough subgrade in advance of fine grading are subsidiary to this Item. Maintenance of a moist condition of the subgrade in advance of fine-grading and concrete is subsidiary work, as provided above.

Item 360: Concrete Pavement
Item 420: Concrete Substructures
Item 421: Hydraulic Cement Concrete

For the Department's concrete cylinder split samples, transport the test cylinders to the Houston District Laboratory located at 7600 Washington Avenue in Houston, or to the appropriate Area Laboratory, when applicable. Transporting the test cylinders is subsidiary to the various bid items.

The approach pavement is paid for under the Item, "Concrete Pavement."

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Highway: IH 45, Etc.

Item 400: Excavation and Backfill for Structures

Plugging existing pipe culverts is subsidiary to the various bid items.

If Recycled Cement Treatment (Type D) is included in the plans, the following additional requirements apply:

1. Use only approved sand, crushed concrete, or salvaged base free from deleterious matter, as aggregate for cement-stabilized backfill.
2. Provide crushed concrete or salvaged base backfill material in accordance with the Item, "Cement Treatment (Plant-Mixed) (Type D)" (base or crushed concrete), except the recycled Type D material must not contain Reclaimed Asphalt Pavement (RAP).
3. For backfill material below the spring line of pipes, use cement-stabilized sand rather than recycled Type D backfill material.
4. For the cement-stabilized sand backfill, use at least 7 percent of hydraulic cement based on the dry weight of the aggregate. The cement content for the crushed concrete and salvaged base is specified in the Item, "Cement Treatment (Plant-Mixed) (Type D)."
5. Place and compact the stabilized backfill material using a gradation that provides a dense mass without segregating and is impervious to passing of water.

Item 421: Hydraulic Cement Concrete

Entrained air is required in all slip formed concrete (bridge rail, concrete traffic barrier, pavement, etc.), but is not required for other structural concrete. Adjust the dosage of air entraining agent for low air content as directed or allowed by the Engineer. If entrained air is provided where not required, do not exceed the manufacturer's recommended dosage.

Item 423: Retaining Walls

Place concrete riprap mow strips for retaining walls as shown on the plans and in accordance with the Item, "Riprap." Use Class B concrete reinforced with No. 4 bars spaced at 18 in. centers each direction and placed 2 in. below the surface. This work is paid for under the Item, "Riprap."

Provide and maintain positive drainage away from the earth wall system, including the leveling pad, for the contract duration.

Item 462: Concrete Box Culverts and Drains
Item 464: Reinforced Concrete Pipe

Concrete collars are subsidiary to the various bid items except for those specified on the plans for stage construction, which are paid for under the Item, "Concrete Substructures" as "Cl C Conc (Collar)."

Rubber gaskets are required for concrete pipe joints except for connections of safety end treatments, driveway culverts, and joints between the existing pipes and extensions.

If performing the work under the Item, "Jacking, Boring, or Tunneling Pipe or Box," use reinforced concrete pipe (except circular bell-and-spigot, arch, or horizontal elliptical pipe).

Open, install, and backfill each section, or a portion of a section, in the same day at locations requiring pipe culverts under existing roadways.

Place the pipe drains across existing roadways half at a time to allow passage of traffic. No trenches may remain open overnight.

Known locations of existing stub-outs are shown on the plans, but these stub-outs may be in a different position or condition. Delays, inconveniences, or additional work required will not be a basis for additional compensation.

Provide leave-outs or holes in the proposed storm drain structures and pipes for drainage during interim construction. This work is subsidiary to the various bid items.

The flowline elevations of side road structures are based on the proposed ditches. Field-verify these elevations and adjust them as necessary to meet the field conditions. Before placing these structures, prepare and submit for approval, the data (revised elevation, alignment, length, etc.) for the adjusted structures.

If groundwater is encountered while installing the storm drain system, install a suitable dewatering system to facilitate construction of the storm drains. The costs for materials and labor required to install and maintain this system are subsidiary to the Item, "Reinforced Concrete Pipe."

Item 465: Junction Boxes, Manholes, and Inlets

If required on the plans, build manholes and inlets to stage 1 construction, cover with temporary pavement, and complete in a later phase of construction. This temporary covering and pavement are subsidiary to the various bid items.

Construct manholes and inlets in graded areas, first to an elevation at least 4 in. above the top of the highest entering pipe and cover with a wooden cover. Complete the construction of such manholes and inlets to the finished elevation as shown on the plans when completing the grading work for such manholes and inlets. Adjust the final elevation, if required, since this elevation is approximate.

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Construct manholes and inlets in paved areas to an elevation so their temporary wooden covers are flush with the surface of the base material.

Do not leave excavations or trenches open overnight.

Items 496: Removing Structures
Items 497: Sale of Salvageable Material

Do not permit debris resulting from the structure removal or construction activities to enter a natural or manmade waterway such as drainage channels, rivers, streams, bays, etc. Remove debris which falls into such waterways. This work is subsidiary to the Item, "Removing Structures."

Item 502: Barricades, Signs, and Traffic Handling

Use a traffic control plan for handling traffic through the various phases of construction. Follow the phasing sequence unless otherwise agreed upon by the Area Engineer and the Project Manager. Ensure this plan conforms to the latest "Texas Manual on Uniform Traffic Control Devices" and the latest Barricade and Construction (BC) Standard Sheets. The latest versions of Work Zone Standard Sheets WZ (BTS-1) and WZ (BTS-2) are the traffic control plan for the signal installations.

Submit changes to the traffic control plan to the Area Engineer. Provide a layout showing the construction phasing, signs, striping, and signalizations for changes to the original traffic control plan.

Furnish and maintain the barricades and warning signs, including the necessary temporary and portable traffic control devices, during the various phases of construction. Place and construct these barricades and warning signs in accordance with the latest "Texas Manual on Uniform Traffic Control Devices" for typical construction layouts.

Cover work zone signs when work related to the signs is not in progress, or when any hazard related to the signs no longer exists.

Keep the delineation devices, signs, and pavement markings clean. This work is subsidiary to the Item, "Barricades, Signs, and Traffic Handling."

If a section is not complete before the end of the workday, pull back the base material to the existing pavement edge on a 6H: 1V slope. Edge drop-offs during the hours of darkness are not permitted.

Before detouring traffic onto the mainlane shoulders, remove dirt, debris, vegetation, and other deleterious material from the surface of the shoulders. Appropriately sign the detour in an approved manner. This work is subsidiary to the various bid items.

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Highway: IH 45, Etc.

Coordinate and schedule the work with the appropriate Metro representative if requiring access to the High Occupancy Vehicle lanes.

Cover or remove the permanent signs and construction signs that are incorrect or that do not apply to the current situation for a particular phase.

Replace the overhead signs, informational signs, and exit signs to be removed, with temporary signs providing the correct information to the traveling public. Size the replacement signs and include them in the traffic control plan.

Do not mount signs on drums or barricades, except those listed in the latest Barricades and Construction standard sheets.

Use traffic cones for daytime work only. Replace the cones with plastic drums during nighttime hours.

Place positive barriers to protect drop-off conditions greater than 2 ft. within the clear zone that remain overnight.

Do not reduce the existing number of lanes open to traffic except as shown on the following time schedule:

One Lane Closure

Day	Daytime Closure Hours	Nighttime Closure Hours	Restricted Hours Subject to Lane Assessment Fee
Monday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Tuesday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Wednesday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Thursday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Friday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Saturday	NA	NA	NA
Sunday	NA	NA	NA

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Highway: IH 45, Etc.

Two Lane Closure

Day	Daytime Closure Hours	Nighttime Closure Hours	Restricted Hours Subject to Lane Assessment Fee
Monday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Tuesday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Wednesday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Thursday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Friday	9:00 AM - 3:00 PM	NA	5:00 AM - 9:00 AM 3:00 PM - 9:00 PM
Saturday	NA	NA	NA
Sunday	NA	NA	NA

The above times are approved for the traffic control conditions listed. The Area Engineer may approve other closure times if traffic counts warrant. The Area Engineer may reduce the above times for special events.

Law enforcement assistance will be required for this project and is expected to be required for major traffic control changes and lane closures. Coordinate with local law enforcement and arrange for law enforcement as directed or agreed by the Engineer. Before payment will be made, complete the "Daily Report on Law Enforcement Force Account Work" (Form 318), provided by the Department and submit daily invoices that agree with this form for any day during the month in which approved services were provided.

Provide full-time, off-duty, uniformed, certified peace officers, as part of traffic control operations. The peace officers must be able to show proof of certification by the Texas Commission on Law Enforcement Officers Standards. The cost of the officers is paid for on a force account basis.

A minimum of 7 days in advance of any total closure, notify the Houston District Public Information Office of which roadways, ramps, intersections, or lanes will be closed, the dates they will remain closed, and when they will be opened again to traffic.

A minimum of 7 days in advance of any total closure, place a Portable Changeable Message (PCM) sign at the location of each total closure which informs the traveling public of the details of the closure. Alternately, if the Traffic Control Plan provides a positive barrier at the location, a non-trailer mounted static message board sign behind the positive barrier may be used in place of a PCM.

Minimize the number of working days for street closures. The following table lists the maximum number of working days allowed for each street closure. The closure period for each

intersection occurs only during the phase when constructing that street, unless otherwise directed. Reopen the street within the number of working days allowed; otherwise the Engineer may cease construction activities not affiliated with reopening the closed street, until it fully reopens to the traveling public. Time charges will not be suspended nor increased to compensate for this occurrence.

Street Name	Number of Working Days Allowed for Closure
SH 6 Frontage Road EB/WB Sta 14+00 to Sta 19+20	14
IH 45 Westbound Sta 12+96.72 to Sta 28+10.50	14

Before closing any City of Houston sidewalk, one or more city street lanes, or entire city streets during construction, obtain a permit to do so from the City. Obtain the required permit in person at the City of Houston Permit Office or apply online at https://geohub.houstontx.gov/

The Contractor Force Account "Safety Contingency" that has been established for this project is intended to be utilized for work zone enhancements, to improve the effectiveness of the Traffic Control Plan, that could not be foreseen in the project planning and design stage. These enhancements will be mutually agreed upon by the Engineer and the Contractor's Responsible Person based on weekly or more frequent traffic management reviews on the project. The Engineer may choose to use existing bid items if it does not slow the implementation of enhancement.

Item 504: Field Office and Laboratory

Furnish one Type E structure for the field office. Ensure the windows for the structure have burglar bars.

Provide a Type E field office meeting the requirements of a Type C structure. Provide this as a single structure with a minimum of 500 sq. ft. of floor space and 3 rooms. Provide the structure with the following facilities. The cost of providing these items is subsidiary to this bid Item:

1. Three desks with 3 swivel chairs, two 5-drawer file cabinets and 3 straight back chairs.
2. Potable water with an electric water cooler, a cup dispenser, and cups.
3. Adequate heating, air conditioning, lighting, and a sufficient number of electrical outlets.
4. A commercially available toilet or equivalent facility for the field office and each laboratory.
5. Provide internet connectivity, a suitable printer/copier/fax machine for the field office, as approved by the Engineer.

Provide a fenced enclosure approximately 100 ft. by 200 ft. Provide an appropriate parking area covered with a suitable base material and with a minimum of 2 security lights, one on each end of the lot. Cost of the work and materials to provide the enclosure are subsidiary to the various bid items.

Piped-in water to the Engineer's building will not be required, but furnish water for curing concrete test specimens.

The above requirements are subsidiary to the various bid items.

Assume ownership of temporary chain link security fences.

Equip each field office with a first aid kit and at least a 20 lb. ABC type fire extinguisher.

Item 506: Temporary Erosion, Sedimentation and Environmental Controls

A Storm Water Pollution Prevention Plan (SWP3) is required. Since the disturbed area is more than 5 acres, a "Notice of Intent" (NOI) is also required.

Use appropriate measures to prevent, minimize, and control the spill of hazardous materials in the construction staging area. Remove and dispose of materials in compliance with State and Federal laws.

Before starting construction, review with the Engineer the SWP3 used for temporary erosion control as outlined on the plans. Before construction, place the temporary erosion and sedimentation control features as shown on the SWP3.

Schedule the seeding or sodding work as soon as possible. The project schedule provides for a vegetation management plan.

After completing earthwork operations, restore and reseed the disturbed areas in accordance with the Department's specifications for permanent or temporary erosion control.

Implement temporary and permanent erosion control measures to comply with the National Pollution Discharge Elimination System (NPDES) general permit under the Clean Water Act.

Before starting grading operations and during the project duration, place the temporary or permanent erosion control measures to prevent sediment from leaving the right of way and protect environmental resources.

Item 512: Portable Traffic Barrier

Transport Low Profile Concrete Barriers (LPCB) used for traffic handling from the Department's stockpile located on the north side of IH 610 at Long Drive.

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Where required by the Engineer, provide anchor pins for Type 2 Low Profile Concrete Barriers (LPCB) as shown on the current LPCB standard. Anchor pins are subsidiary to the LPCB.

After completing the project, return Low Profile Concrete Barriers (LPCB) used for traffic handling, to the Department's stockpile located on the north side of IH 610 at Long Drive. After completing the project, return the associated LPCB connecting hardware to the area office or as directed.

Item 530: Intersections, Driveways, and Turnouts
Item 531: Sidewalks

An air-entraining admixture is not required.

For concrete curbs, use Grade 7 aggregate conforming to Section 421.2.6 of the Item, "Hydraulic Cement Concrete."

For driveways and turnouts, coarse aggregate Grade No. 3 through No. 8 conforming to the gradation requirements specified in the Item, "Hydraulic Cement Concrete" will be permitted.

For reinforcing steel in sidewalks and pedestrian ramps, use No. 4 bars at a maximum 18 in. spacing center-to-center in both directions.

Item 540: Metal Beam Guard Fence

Painting the timber posts is not required.

Use timber posts for galvanized steel metal beam guard fence, except for anchorage at turned down ends.

Furnish and install wood blocks between the rail elements and the timber posts as detailed on the plans. These block-outs are subsidiary to this bid Item.

The quantity of the metal beam guard fence is subject to change.

Provide a mow strip as shown on the plans, at metal beam guard fence locations, including any guardrail end treatments.

Galvanize the rail elements supplied for this project by using a Type II Zinc Coating.

At locations requiring attachment of Metal Beam Guard Fence (MBGF) to concrete railing or concrete traffic barrier, repair and fill any existing holes in the railing or barrier that are not in the correct location for attaching the new MBGF. Perform this work in accordance with the Item, "Concrete Structure Repair." Existing anchor bolt holes that cannot be utilized must be filled with an epoxy grout before drilling new holes. Then core-drill new holes in the correct locations and repair any resulting spalls at no expense to the Department. This work is considered subsidiary to the MBGF transition section (Item 540).

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Highway: IH 45, Etc.

Item 542: Removing Metal Beam Guard Fence

Remove and assume ownership of unsalvageable metal beam guard fence rail elements and posts. The removal items belonging to MBGF and SGT will become the property of the Contractor. The price for these items will be full compensation for the removal and disposal of the Guard Rail.

Replace removed wood posts which are unusable because of damage by the Contractor, at no expense to the Department.

Item 618: Conduit
Item 620: Electrical Conductors
Item 628: Electrical Services

If the specifications for electrical items require UL-listed products, this means UL-listed or CSA-listed.

Item 618: Conduit

When backfilling bore pits, ensure that the conduit is not damaged during installation or due to settling backfill material. Compact select backfill in 3 equal lifts to the bottom of the conduit; or if using sand, place it 2 in. above the conduit. Ensure backfill density is equal to that of the existing soil. Prevent material from entering the conduit.

Construct bore pits a minimum of 5 ft. from the edge of the base or pavement. Close the bore pit holes overnight.

Unless otherwise shown on the plans, install underground conduit a minimum of 24 in. deep. Install the conduit in accordance with the latest National Electrical Code (NEC) and applicable Department standard sheets. Place conduit under driveways or roadways a minimum of 24 in. below the pavement surface.

If using casing to place bored conduit, the casing is subsidiary to the conduit.

If placing the conduit under existing pavement to reach the service poles, bore the conduit in place and extend it a minimum distance of 5 ft. beyond the edge of shoulder or the back of curb.

Where PVC, duct cable, and HDPE conduit 1 in. and larger is allowed and installed per Department standards, provide a PVC elbow in place of the galvanized rigid metal elbow required by the Electrical Details standards. Ensure the PVC elbow is of the same schedule rating as the conduit to which it is connected. Use only a flat, high tensile strength polyester fiber pull tape to pull conductors through the PVC conduit system.

Remove conductor and conduit to be abandoned to 1 ft. below the ground level. This work is subsidiary to the various bid items.

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Do not use cast iron junction boxes in concrete traffic barriers and single slope traffic barriers. Use polymer concrete junction boxes as shown on standard sheet ED(4)-14. Mount the junction boxes flush (+ 0 in., - 1/2 in.) with the concrete surface of the concrete barrier.

Locate the underground utilities within the project limits. Provide the equipment necessary for locating these utilities, locate, and mark them before starting any excavation work in the area. This work is subsidiary to the various bid items. If the Contractor damages or cause damage to any existing underground utilities, repair such damage at no cost to the Department.

Ensure the interconnection of new equipment to the existing system does not interfere with the operation of the remaining system components. Ensure the system remains completely operational between the hours of 6:00 a.m. Monday and 12:00 a.m. (midnight) Saturday.

Do not interrupt system operation without coordinating with the Department's operations personnel at Houston Transtar at (713) 881-3285.

Perform work to be done on cables during weekends only.

Provide Liquid-Tight Flexible Metal (LTFM) conduit if the plans refer to flexible metal conduit. Do not use flexible metal conduit.

Unless otherwise shown on the plans, place conduit runs behind curbs at locations where curbs exist.

Use schedule 80 PVC conduit to house conductor runs under paved riprap, roadway, or driveways, unless otherwise shown on the plans.

Use Rigid Metal Conduit (RMC) for exposed conduit.

Before backfilling conduit trenches, place a detectable underground metalized mylar marking tape above the conduit and concrete encasement. Imprint the marking tape with, "TxDOT CONDUIT AND FIBER OPTIC CABLE SYSTEM. CALL (713) 802-5909 BEFORE PROCEEDING" every 18 in. Supplying and installing the marking tapes is subsidiary to the various bid items.

Conduit elbows and rigid metal extensions required when installing PVC conduit systems are subsidiary to the various bid items.

Install a continuous bare or green insulated copper wire No. 8 AWG or larger in every conduit throughout the electrical system in accordance with the Electrical Detail Standard Sheets, and the latest edition of the NEC.

Provide a single 1/C #14 insulated wire in conduit runs which have been identified in the plans to carry fiber optic cable. Provide UL-listed solid copper wire with orange color low density polyethylene insulation, suitable for conduit installation, rated for a temperature range of -20 C to +60 C and a voltage rating of 600V. This wire will serve as a tracer, or locate, wire for

locating underground conduit containing fiber optic cabling and will be paid for under Item 620, "Electrical Conductors."

Item 620: Electrical Conductors

Test each wire of each cable or conductor after installation. Incomplete circuits or damage to the wire or the cable are cause for immediate rejection of the entire cable being tested. Remove and replace the entire cable at no expense to the Department. Also test the replacement cable after installation.

When pulling cables or conductors through the conduit, do not exceed the manufacturer's recommended pulling tensions. Lubricate the cables or conductors with a lubricant recommended by the cable manufacturer.

For both transformer and shoe-base type illumination poles, provide double-pole breakaway fuse holders as shown on the Department's Construction Division (CST) material producers list. Check the latest link on the Department's website for this list. The category is "Roadway Illumination and Electrical Supplies." The fuse holder is shown on the list under Items 610 and 620. Provide 10 Amp time delay fuses.

Ensure that circuits test clear of faults, grounds, and open circuits.

Split bolt connectors are allowed only for splices on the grounding conductors.

For Roadside Flashing Beacon Assemblies (Item 685) and Pedestal Pole Assemblies (Item 687) within the project, provide single-pole breakaway disconnects as shown on the Construction Division (CST) material producers list. Check the latest link on the Department's website for this list. The category is "Roadway Illumination and Electrical Supplies." The fuse holder is shown on the list under Item 685. For underground (hot) conductors, install a breakaway connector with a dummy fuse (slug). Provide dummy fuse (slug). For grounded (neutral) conductors, install a breakaway connector with a white colored marking and a permanently installed dummy fuse (slug).

For electrical licensing and electrical certification requirements for this project, see Item 7 of the Standard Specifications and any applicable special provisions to Item 7.

Item 624: Ground Boxes

The ground box locations are approximate. Alternate ground box locations may be used as directed, to avoid placing in sidewalks or driveways.

Ground metal ground box covers. Bond the ground box cover and ground conductors to a ground rod located in the ground box and to the system ground.

Ground the existing metal ground box covers as shown on the latest standard sheet ED (4)-14.

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During construction and until project completion, provide personnel and equipment necessary to remove ground box lids for inspection. Provide this assistance within 24 hours of notification.

Construct concrete aprons in accordance with the latest standard sheet ED (4)-14. Make the depth of the concrete apron the same as the depth of the ground box, except for Type 1 and Type 2 ground boxes. For Type 1 or Type 2 ground boxes, construct the concrete apron in accordance with details shown on the "Ground Box Details Installations" standard.

Item 628: Electrical Services

Verify and coordinate the electrical service location with the engineering section of the appropriate utility district or company.

Identify the electrical service pole with an address number assigned by the Utility Service Provider. Provide 2-in. numerals visible from the highway. Provide numbers cut out aluminum figures nailed to wood poles or painted figures on steel poles or service cabinets.

Item 644: Small Roadside Sign Assemblies

Sign locations shown on the plans are approximate. Before placing them, obtain approval of and then stake the exact locations for these signs.

Use the Texas Universal Triangular Slip Base with the concrete foundation for small ground mounted signs, unless otherwise shown in the plans.

Remove existing street name signs from existing stop signs and re-install them above the new stop signs. Removing and re-installing existing street name signs is subsidiary to the Item, "Small Roadside Sign Assemblies."

When design details are not shown on the plans, provide signs and arrows conforming to the latest "Standard Highway Sign Designs for Texas" manual.

Use Type E Super High Specific Intensity (Fluorescent Prismatic) yellow green reflective sheeting background to fabricate school signs (S1-1, S3-1, S4-3, S5-1, W16-2, SW16-9p, and SW16-7pL(R)).

Assume ownership of the removed existing signposts. Store removed sign panels at the Contractor's field office, to be picked up by the maintenance office. This work is subsidiary to this item.

Locations of the relocated signs are approximate. Before placing them, obtain approval of and then stake the exact locations for these signs.

Replace existing signs that become damaged during relocation at no expense to the Department.

County: HARRIS, Etc. **Control:** 0500-03-644, Etc.

Highway: IH 45, Etc.

Item 662: Work Zone Pavement Markings

At the end of each workday, mark roadways that remain open to traffic during construction operations with standard pavement markings, in accordance with the latest "Texas Manual on Uniform Traffic Control Devices."

Using raised markers for removable work zone pavement markings on final concrete surfaces is optional.

For transition lane lines and detour lane lines, use raised pavement markers as shown for solid lines on the latest Barricade and Construction standard sheet for "Work Zone Pavement Marking Details."

Item 662: Work Zone Pavement Markings
Item 6038: Multipolymer Pavement Markings (MPM)

Use Type III glass beads for thermoplastic and multipolymer pavement markings.

Use a 0.100 in. (100 mil) thickness for thermoplastic pavement markings, measured to the top of the thermoplastic, not including the exposed glass beads.

Use a 0.022 in. (22 mil) thickness for multipolymer pavement markings, measured to the top of the multipolymer, not including the exposed glass beads.

For roadways with asphalt surfaces to be striped with work zone or permanent thermoplastic markings, the Contractor has the option to apply paint and beads markings for a maximum 30-day period until placing the thermoplastic markings, or until starting the succeeding phase of work on the striped area. Maintain the paint and beads markings, at no expense to the Department, until placing the thermoplastic markings or starting the succeeding phase of work on the striped area. The work zone markings, whether paint and beads or thermoplastic, are paid under the Item, "Work Zone Pavement Markings" and the markings are paid for only once for the given phase of construction.

If using paint and bead markings as described above, purchase the traffic paint from the open market.

If the Type II markings become dirty and require cleaning by washing, brushing, compressed air, or other approved methods before applying the Type I thermoplastic markings, this additional cleaning is subsidiary to the Item, "Retroreflectorized Pavement Markings."

Establish the alignment and layout for work zone striping and permanent striping.

Stripe all roadways before opening them to traffic.

Place pavement markings under these items in accordance with details shown on the plans, the latest "Texas Manual on Uniform Traffic Control Devices," or as directed.

County: HARRIS, Etc. **Control:** 0500-03-644, Etc.

Highway: IH 45, Etc.

When design details are not shown on the plans, provide pavement markings for arrows, words, and symbols conforming to the latest "Standard Highway Sign Designs for Texas" manual.

Place the pedestrian crosswalk pavement markings only after the pedestrian signals and push buttons are installed and operating.

Item 677: Eliminating Existing Pavement Markings and Markers

Remove existing pavement markings on concrete or asphalt surfaces by flail milling or as directed. Do not use flail milling on grooved concrete or porous asphalt.

Item 678: Pavement Surface Preparation for Markings

Do not blast clean asphalt concrete pavement. Clean asphalt concrete pavement as required under the applicable specifications or as directed.

On new concrete pavement or on existing concrete pavement when placing a new stripe on a new location, remove the curing compounds and contamination from the pavement surface by flail milling or as directed. In addition, air-blast the surface with compressed air just before placing the new stripe.

On existing concrete pavement when placing a new stripe on an existing location, after removing the existing stripe under the Item, "Eliminating Existing Pavement Markings and Markers," air-blast the surface with compressed air just before placing the new stripe.

Do not clean concrete pavement by grinding.

Item 730: Roadside Mowing
Item 734: Litter Removal
Item 738: Cleaning and Sweeping Highways

Mow areas of existing vegetation, collect and dispose of litter, and sweep the roadway within the project limits according to the following chart for the duration of the project or as directed. This work is paid for under their respective bid items.

Roadside Mowing	Litter Removal
3 cycles	cycles

Item 6185: Truck Mounted Attenuator (TMA) and Trailer Attenuator (TA)

A shadow vehicle with Truck Mounted Attenuators (TMAs) or Trailer Attenuators (TAs) is required as shown on the appropriate Traffic Control Plan (TCP) sheets. TMAs/TAs must meet the requirements of the Compliant Work Zone Traffic Control Device List.

Level 3 Compliant TMAs/TAs are required for this project.

County: HARRIS, Etc. **Control:** 0500-03-644, Etc.

Highway: IH 45, Etc.

A total of one (1) shadow vehicle with a TMA/TA is required for the work with the exception of Pavement Marking Operations. The Contractor is responsible for determining if one or more of these operations will be ongoing at the same time to determine the total number of TMAs/TAs needed on the project.

A total of three (3) shadow vehicles with a TMA/TA are required for Pavement Marking Operations. The Contractor is responsible for determining if one or more of these operations will be ongoing at the same time to determine the total number of TMAs/TAs needed on the project.

In addition to the shadow vehicles with TMAs/TAs that are specified as being required on the TCP layout sheets for this project, provide additional shadow vehicles with TMAs/TAs as shown on the TCP Standard sheets. The Contractor is responsible for determining if one or more of these operations will be ongoing at the same time to determine the total number of TMAs/TAs needed on the project.

Item 7361

For bidding purposes, the 5 pumps shown in the plans should be bid considering non-domestic materials. This only applies to the pumps and no other components of the pump station.

Item 7363

For bidding purposes, the 3 pumps shown in the plans should be bid considering non-domestic materials. This only applies to the pumps and no other components of the pump station.

Item 7364

For bidding purposes, the 3 pumps shown in the plans should be bid considering non-domestic materials. This only applies to the pumps and no other components of the pump station.

Basis of Estimate

Item	Description	Limit and Rate	Unit
260	Lime Treatment (Road-Mixed) For materials used as subgrade * • Lime(HYD, COM, or QK)(SLRY) or QK(DRY)	 6 % by weight based on 100 Lb. / Cu. Ft. subgrade	SY TON

* If used in existing roadway base, rate will be determined on a case-by-case basis.

CONTROL : 0500-03-644, ETC
PROJECT : C 500-3-644, ETC
HIGHWAY : IH 45, ETC
COUNTY : HARRIS, ETC

TEXAS DEPARTMENT OF TRANSPORTATION

GOVERNING SPECIFICATIONS AND SPECIAL PROVISIONS

ALL SPECIFICATIONS AND SPECIAL PROVISIONS APPLICABLE TO THIS PROJECT ARE IDENTIFIED AS FOLLOWS:

STANDARD SPECIFICATIONS: ADOPTED BY THE TEXAS DEPARTMENT OF TRANSPORTATION NOVEMBER 1, 2014. STANDARD SPECIFICATIONS ARE INCORPORATED INTO THE CONTRACT BY REFERENCE.

ITEMS 1 TO 9 INCL., GENERAL REQUIREMENTS AND COVENANTS
ITEM 100 PREPARING RIGHT OF WAY (103)
ITEM 104 REMOVING CONCRETE
ITEM 105 REMOVING TREATED AND UNTREATED BASE AND ASPHALT PAVEMENT
ITEM 110 EXCAVATION (132)
ITEM 132 EMBANKMENT (100)(160)(204)(210)(216)(260)(400)
ITEM 161 COMPOST (160)
ITEM 162 SODDING FOR EROSION CONTROL (166)(168)
ITEM 164 SEEDING FOR EROSION CONTROL (162)(166)(168)
ITEM 166 FERTILIZER (520)
ITEM 168 VEGETATIVE WATERING
ITEM 247 FLEXIBLE BASE (105)(204)(210)(216)(520)
ITEM 260 LIME TREATMENT (ROAD-MIXED) (105)(132)(204)(210)(216) (247)(300)(310)(520)<3096>
ITEM 276 CEMENT TREATMENT (PLANT-MIXED) (204)(210)(216)(247)(300) (310)<520><3096>
ITEM 292 ASPHALT TREATMENT (PLANT-MIXED) (300)(301)(320)(520)(585) <3096>
ITEM 340 DENSE-GRADED HOT-MIX ASPHALT (SMALL QUANTITY) (300)(301) <316>(320)<340><341><347><348>(520)(585)<3079><3081><3082> <3096>
ITEM 360 CONCRETE PAVEMENT (421)(422)(438)(440)(529)(585)
ITEM 400 EXCAVATION AND BACKFILL FOR STRUCTURES (110)(132)(401) (402)(403)(416)(420)(421)(423)
ITEM 402 TRENCH EXCAVATION PROTECTION
ITEM 403 TEMPORARY SPECIAL SHORING (410)(411)(423)
ITEM 416 DRILLED SHAFT FOUNDATIONS (405)(420)(421)(423)(440)(448)
ITEM 420 CONCRETE SUBSTRUCTURES (400)(404)(421)(422)(426)(427) (440)(441)(448)
ITEM 423 RETAINING WALLS (110)(132)(216)(400)(416)(420)(421)(424)

(440)(445)<458><556>
ITEM 432 RIPRAP (247)(420)(421)(431)(440)
ITEM 460 CORRUGATED METAL PIPE (400)(402)(403)(445)(467)(476)
ITEM 462 CONCRETE BOX CULVERTS AND DRAINS (400)(402)(403)(420)
(421)(422)(424)(440)(464)(476)
ITEM 464 REINFORCED CONCRETE PIPE (400)(402)(403)(467)(476)
ITEM 465 JUNCTION BOXES, MANHOLES, AND INLETS (400)(420)(421)(424)
(440)(471)
ITEM 467 SAFETY END TREATMENT (400)(420)(421)(432)(440)(442)(445)
(460)(464)
ITEM 476 JACKING, BORING, OR TUNNELING PIPE OR BOX (402)(403)(460)
(462)(464)
ITEM 496 REMOVING STRUCTURES
ITEM 500 MOBILIZATION
ITEM 502 BARRICADES, SIGNS, AND TRAFFIC HANDLING
ITEM 504 FIELD OFFICE AND LABORATORY
ITEM 506 TEMPORARY EROSION, SEDIMENTATION, AND ENVIRONMENTAL
CONTROLS (161)(432)(556)
ITEM 512 PORTABLE TRAFFIC BARRIER (420)(421)(424)(440)(442)
ITEM 529 CONCRETE CURB, GUTTER, AND COMBINED CURB AND GUTTER (360)
(420)(421)(440)
ITEM 530 INTERSECTIONS, DRIVEWAYS, AND TURNOUTS (247)(260)(263)
(275)(276)(292)(316)(330)(334)(340)<341>(360)(421)(440)
<3076>
ITEM 531 SIDEWALKS (104)(360)(420)(421)(440)(530)
ITEM 540 METAL BEAM GUARD FENCE (421)(441)(445)<492>(529)
ITEM 542 REMOVING METAL BEAM GUARD FENCE
ITEM 544 GUARDRAIL END TREATMENTS
ITEM 550 CHAIN LINK FENCE (421)(445)
ITEM 618 CONDUIT (400)(476)
ITEM 620 ELECTRICAL CONDUCTORS (610)(628)
ITEM 624 GROUND BOXES <302>(420)(421)(432)(440)(618)(620)
ITEM 627 TREATED TIMBER POLES
ITEM 628 ELECTRICAL SERVICES (441)(445)(449)(618)(620)(627)(656)
ITEM 662 WORK ZONE PAVEMENT MARKINGS (666)(668)(672)(677)
ITEM 666 RETROREFLECTORIZED PAVEMENT MARKINGS (316)(502)(662)(677)
(678)<6438>
ITEM 668 PREFABRICATED PAVEMENT MARKINGS (678)
ITEM 672 RAISED PAVEMENT MARKERS (677)(678)
ITEM 677 ELIMINATING EXISTING PAVEMENT MARKINGS AND MARKERS (300)
(302)(316)<3096>
ITEM 678 PAVEMENT SURFACE PREPARATION FOR MARKINGS (677)

SPECIAL PROVISIONS: SPECIAL PROVISIONS WILL GOVERN AND TAKE
---------- PRECEDENCE OVER THE SPECIFICATIONS ENUMERATED
HEREON WHEREVER IN CONFLICT THEREWITH.

SPECIAL LABOR PROVISIONS FOR STATE PROJECTS (000---008)
SPECIAL PROVISION "NONDISCRIMINATION" (000---002)
SPECIAL PROVISION "SMALL BUSINESS ENTERPRISE IN STATE FUNDED PROJECTS
" (000---009)
SPECIAL PROVISION "SCHEDULE OF LIQUIDATED DAMAGES" (000--1243)

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SPECIAL PROVISION "CERTIFICATE OF INTERESTED PARTIES (FORM 1295)"
                    (000--1557)
SPECIAL PROVISION "NOTICE OF CONTRACTOR PERFORMANCE EVALUATIONS"
                    (000---659)
SPECIAL PROVISION  TO ITEM     1  (001---001)
SPECIAL PROVISIONS TO ITEM     2  (002---013)(002---014)(002---015)
SPECIAL PROVISIONS TO ITEM     3  (003---011)(003---013)
SPECIAL PROVISIONS TO ITEM     5  (005---002)(005---003)(005---005)
SPECIAL PROVISIONS TO ITEM     6  (006---001)(006---012)(006---040)
SPECIAL PROVISIONS TO ITEM     7  (007---004)(007---008)(007---010)
                                  (007---011)(007---013)
SPECIAL PROVISIONS TO ITEM     8  (008---030)(008---033)(008---045)
                                  (008---054)(008---055)
SPECIAL PROVISIONS TO ITEM     9  (009---010)(009---016)
SPECIAL PROVISIONS TO ITEM   132  (132---001)(132---002)
SPECIAL PROVISION  TO ITEM   247  (247---005)
SPECIAL PROVISION  TO ITEM   300  (300---020)
SPECIAL PROVISION  TO ITEM   302  (302---003)
SPECIAL PROVISION  TO ITEM   316  (316---002)
SPECIAL PROVISION  TO ITEM   334  (334---004)
SPECIAL PROVISION  TO ITEM   340  (340---004)
SPECIAL PROVISION  TO ITEM   341  (341---004)
SPECIAL PROVISION  TO ITEM   342  (342---005)
SPECIAL PROVISION  TO ITEM   347  (347---003)
SPECIAL PROVISION  TO ITEM   348  (348---004)
SPECIAL PROVISION  TO ITEM   360  (360---001)
SPECIAL PROVISION  TO ITEM   420  (420---001)
SPECIAL PROVISION  TO ITEM   421  (421---012)
SPECIAL PROVISION  TO ITEM   423  (423---007)
SPECIAL PROVISION  TO ITEM   426  (426---005)
SPECIAL PROVISION  TO ITEM   427  (427---003)
SPECIAL PROVISION  TO ITEM   438  (438---002)
SPECIAL PROVISION  TO ITEM   440  (440---005)
SPECIAL PROVISION  TO ITEM   441  (441---004)
SPECIAL PROVISION  TO ITEM   442  (442---001)
SPECIAL PROVISION  TO ITEM   446  (446---005)
SPECIAL PROVISION  TO ITEM   448  (448---001)
SPECIAL PROVISION  TO ITEM   449  (449---002)
SPECIAL PROVISION  TO ITEM   462  (462---002)
SPECIAL PROVISION  TO ITEM   464  (464---001)
SPECIAL PROVISION  TO ITEM   465  (465---001)
SPECIAL PROVISION  TO ITEM   502  (502---008)
SPECIAL PROVISION  TO ITEM   506  (506---005)
SPECIAL PROVISION  TO ITEM   520  (520---002)
SPECIAL PROVISION  TO ITEM   540  (540---001)
SPECIAL PROVISION  TO ITEM   656  (656---001)
SPECIAL PROVISION  TO ITEM   666  (666---007)
SPECIAL PROVISION  TO ITEM   672  (672---001)
SPECIAL PROVISION  TO SPECIAL SPECIFICATION ITEM  3096  (3096--005)
SPECIAL PROVISION  TO SPECIAL SPECIFICATION ITEM  6185  (6185--002)


SPECIAL SPECIFICATIONS:
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ITEM 3076 DENSE-GRADED HOT-MIX ASPHALT <300><301><316><320><340>
<341><342><347><348><520><585><3079><3081><3082><3096>
ITEM 3079 PERMEABLE FRICTION COURSE (PFC) <300><301><320><342><520>
<585><3096>
ITEM 3081 THIN OVERLAY MIXTURES (TOM) <300><301><320><347><520>
<585><3096>
ITEM 3082 THIN BONDED FRICTION COURSES <210><300><301><320><342>
<348><520><585><3079><3096>
ITEM 3096 ASPHALTS, OILS, AND EMULSIONS <3096>
ITEM 4008 TRENCH DRAIN
ITEM 6001 PORTABLE CHANGEABLE MESSAGE SIGN
ITEM 6027 PREPARATION OF EXISTING CONDUITS, GROUND BOXES, OR
MANHOLES (465)(618)(624)
ITEM 6038 MULTI-POLYMER PAVEMENT MARKINGS (MPM) (677)
ITEM 6185 TRUCK MOUNTED ATTENUATOR (TMA) AND TRAILER ATTENUATOR (TA)
ITEM 6438 MOBILE RETROREFLECTIVITY DATA COLLECTION FOR PAVEMENT
MARKINGS
ITEM 7361 AUTOMATIC PUMPING STATION <132><420><421>
ITEM 7363 AUTOMATIC PUMPING STATION
ITEM 7364 AUTOMATIC PUMPING STATION <132><420><421><446>

GENERAL: THE ABOVE-LISTED SPECIFICATION ITEMS ARE THOSE UNDER WHICH
------- PAYMENT IS TO BE MADE. THESE, TOGETHER WITH SUCH OTHER
PERTINENT ITEMS, IF ANY, AS MAY BE REFERRED TO IN THE ABOVE-
LISTED SPECIFICATION ITEMS, AND INCLUDING THE SPECIAL
PROVISIONS LISTED ABOVE, CONSTITUTE THE COMPLETE SPECIFI-
CATIONS FOR THIS PROJECT.

Control	**0500-03-644, ETC.**
Project	**C 500-3-644, ETC.**
Highway	**IH 45, ETC.**
County	**HARRIS, ETC.**

SMALL BUSINESS ENTERPRISE REQUIREMENTS

The following goal for small business enterprises is established:

SBE
0.0%

CHILD SUPPORT STATEMENT

Under Section 231.006, Family Code, the vendor or applicant certifies that the individual or business entity named in this contract, bid, or application is not ineligible to receive the specified grant, loan, or payment and acknowledges that this contract may be terminated and payment may be withheld if this certification is inaccurate.

CONFLICT OF INTEREST CERTIFICATION

Pursuant to Texas Government Code Section 2261.252(b), the Department is prohibited from entering into contracts in which Department officers and employees have a financial interest.

By signing the Contract, the Contractor certifies that it is not prohibited from entering into a Contract with the Department as a result of a financial interest as defined under Texas Government Code Section 2261.252(b), and that it will exercise reasonable care and diligence to prevent any actions or conditions that could result in a conflict of interest with the Department.

The Contractor also certifies that none of the following individuals, nor any of their family members within the second degree of affinity or consanguinity, owns 1% or more interest or has a financial interest as defined under Texas Government Code Section 2261.252(b) in the Contractor:

- Any member of the Texas Transportation Commission; and
- The Department's Executive Director, General Counsel, Chief of Procurement and Field Support Operations, Director of Procurement, and Director of Contract Services.

Violation of this certification may result in action by the Department.

E-VERIFY CERTIFICATION

Pursuant to Texas Transportation Code §223.051, all TxDOT contracts for construction, maintenance, or improvement of a highway must include a provision requiring Contractors and subcontractors to use the U.S. Department of Homeland Security's E-Verify system to determine employment eligibility. By signing the contract, the Contractor certifies that prior to the award of the Contract:

- the Contractor has registered with and will, to the extent permitted by law, utilize the United States Department of Homeland Security's E-Verify system during the term of the Contract to determine the eligibility of all persons hired to perform duties within Texas during the term of the agreement; and
- the Contractor will require that all subcontractors also register with and, to the extent permitted by law, utilize the United States Department of Homeland Security's E-Verify system during the term of the subcontract to determine the eligibility of all persons hired to perform duties within Texas during the term of the agreement.

Violation of this requirement constitutes a material breach of the Contract, subjects a subcontractor to removal from the Contract, and subjects the Contractor or subcontractors to possible sanctions in accordance with Title 43, Texas Administrative Code, Chapter 10, Subchapter F, "Sanctions and Suspension for Ethical Violations by Entities Doing Business with the Department."

Certification Regarding Disclosure of Public Information

Pursuant to Subchapter J, Chapter 552, Texas Government Code, contractors executing a contract with a governmental body that results in the expenditure of at least $1 million in public funds must:

1) preserve all contracting information* as provided by the records retention requirements applicable to Texas Department of Transportation (TxDOT) for the duration of the contract,
2) on request of TxDOT, promptly provide any contracting information related to the contract that is in the custody or possession of the entity, and
3) on completion of the contract, either:
    A. provide, at no cost to TxDOT, all contracting information related to the contract that is in the custody or possession of the entity, or
    B. preserve the contracting information related to the contract as provided by the records retention requirements applicable to TxDOT

The requirements of Subchapter J, Chapter 552, Government Code, may apply to this contract, and the contractor or vendor agrees that the contract can be terminated if the contractor or vendor knowingly or intentionally fails to comply with a requirement of that subchapter.

By entering into Contract, the Contractor agrees to:

- provide, or make available, to TxDOT and any authorized governmental investigating or auditing agency all records, including electronic and payment records related to the contract, for the same period provided by the records retention schedule applicable to TxDOT, and
- ensure that all subcontracts include a clause requiring the same.

* As defined in Government Code §552.003, "Contracting information" means the following information maintained by a governmental body or sent between a governmental body and a vendor, contractor, potential vendor, or potential contractor:

1) information in a voucher or contract relating to the receipt or expenditure of public funds by a governmental body;
2) solicitation or bid documents relating to a contract with a governmental body;
3) communications sent between a governmental body and a vendor, contractor, potential vendor, or potential contractor during the solicitation, evaluation, or negotiation of a contract;
4) documents, including bid tabulations, showing the criteria by which a governmental body evaluates each vendor, contractor, potential vendor, or potential contractor responding to a solicitation and, if applicable, an explanation of why the vendor or contractor was selected; and
5) communications and other information sent between a governmental body and a vendor or contractor related to the performance of a final contract with the governmental body or work performed on behalf of the governmental body.

CERTIFICATION TO NOT BOYCOTT ISRAEL

Pursuant to Texas Government Code §2271.002, the Department must include a provision requiring a written verification affirming that the Contractor does not boycott Israel, as defined in Government Code §808.001, and will not boycott Israel during the term of the contract. This provision applies to a contract that:

1) is with a Contractor that is not a sole proprietorship,
2) is with a Contractor with 10 or more full-time employees, and
3) has a value of $100,000 or more.

By signing the contract, the Contractor certifies that it does not boycott Israel and will not boycott Israel during the term of this contract. “Boycott” means refusing to deal with, terminating business activities with, or otherwise taking any action that is intended to penalize, inflict economic harm on, or limit commercial relations specifically with Israel, or with a person or entity doing business in Israel or in an Israeli-controlled territory, but does not include an action made for ordinary business purposes.

Violation of this certification may result in action by the Department.

CERTIFICATION TO NOT BOYCOTT ENERGY COMPANIES

Pursuant to Texas Government Code §2274.002, the Department must include a provision requiring a written verification affirming that the Contractor does not boycott energy companies, as defined in Government Code §809.001, and will not boycott energy companies during the term of the contract. This provision applies to a contract that:

1) is with a Contractor that is not a sole proprietorship,
2) is with a Contractor with 10 or more full-time employees, and
3) has a value of $100,000 or more.

By signing the contract, the Contractor certifies that it does not boycott energy companies and will not boycott energy companies during the term of this contract. “Boycott” means taking any action that is intended to penalize, inflict economic harm on, or limit commercial relations with a company because the company: (1) engages in the exploration, production, utilization, transportation, sale, or manufacturing of fossil fuel-based energy and does not commit or pledge to meet environmental standards beyond applicable federal and state law; or (2) does business with a company described by (1).

Violation of this certification may result in action by the Department.

CERTIFICATION TO NOT DISCRIMINATE AGAINST FIREARM ENTITIES OR FIREARM TRADE ASSOCIATIONS

Pursuant to Texas Government Code §2274.002, the Department must include a provision requiring a written verification affirming that the Contractor:

1) does not have a practice, policy, guidance, or directive that discriminates against a firearm entity or firearm trade association, as defined in Government Code §2274.001, and
2) will not discriminate against a firearm entity or firearm trade association during the term of the contract.

This provision applies to a contract that:

1) is with a Contractor that is not a sole proprietorship,
2) is with a Contractor with 10 or more full-time employees, and
3) has a value of $100,000 or more.

By signing the contract, the Contractor certifies that it does not discriminate against a firearm entity or firearm trade association as described and will not do so during the term of this contract. "Discriminate against a firearm entity or firearm trade association" means, with respect to the entity or association, to: (1) refuse to engage in the trade of any goods or services with the entity or association based solely on its status as a firearm entity or firearm trade association; (2) refrain from continuing an existing business relationship with the entity or association based solely on its status as a firearm entity or firearm trade association; or (3) terminate an existing business relationship with the entity or association based solely on its status as a firearm entity or firearm trade association. "Discriminate against a firearm entity or firearm trade association" does not include: (1) the established policies of a merchant, retail seller, or platform that restrict or prohibit the listing or selling of ammunition, firearms, or firearm accessories; (2) a company's refusal to engage in the trade of any goods or services, decision to refrain from continuing an existing business relationship, or decision to terminate an existing business relationship to comply with federal, state, or local law, policy, or regulations or a directive by a regulatory agency, or for any traditional business reason that is specific to the customer or potential customer and not based solely on an entity 's or association's status as a firearm entity or firearm trade association.

Violation of this certification may result in action by the Department.

PROHIBITION ON CERTAIN TELECOMMUNICATIONS EQUIPMENT OR SERVICES

The Federal Register Notice issued the Final Rule and states that the amendment to 2 CFR 200.216 is effective on August 13, 2020. The new 2 CFR 200.471 regulation provides clarity that the telecommunications and video surveillance costs associated with 2 CFR 200.216 are unallowable for services and equipment from these specific providers. OMB's Federal Register Notice includes the new 2 CFR 200.216 and 2 CFR 200.471 regulations.

https://www.federalregister.gov/documents/2020/08/13/2020-17468/guidance-for-grants-and-agreements

Per the Federal Law referenced above, use of services, systems, or services or systems that contain components produced by any of the following manufacturers is strictly prohibited for use on this project. Therefore, for any telecommunications, CCTV, or video surveillance equipment, services or systems cannot be manufactured by, or have components manufactured by:

- Huawei Technologies Company,
- ZTE Corporation (any subsidiary and affiliate of such entities),
- Hyatera Communications Corporation,
- Hangzhou Hikvision Digital Technology Company,
- Dahua Technology Company (any subsidiary and affiliate of such entities).

Violation of this prohibition will require replacement of the equipment at the contractor's expense.

Special Provision to Item 000
Special Labor Provisions for State Projects

1. GENERAL

This is a "Public Works" Project, as provided under Government Code Title 10, Chapter 2258, "Prevailing Wage Rates," and is subject to the provisions of the Statute. No provisions in the Contract are intended to be in conflict with the provisions of the Statute.

The Texas Transportation Commission has ascertained and indicated in the special provisions the regular rate of per diem wages prevailing in each locality for each craft or type of worker. Apply the wage rates contained in the specifications as minimum wage rates for the Contract.

2. MINIMUM WAGES, HOURS AND CONDITIONS OF EMPLOYMENT

All workers necessary for the satisfactory completion of the work are within the purview of the Contract.

Whenever and wherever practical, give local citizens preference in the selection of labor.

Do not require any worker to lodge, board or trade at a particular place, or with a particular person as a condition of employment.

Do not charge or accept a fee of any from any person who obtains work on the project. Do not require any person who obtains work on the project to pay any fee to any other person or agency obtaining employment for the person on the project.

Do not charge for tools or equipment used in connection with the duties performed, except for loss or damage of property. Do not charge for necessary camp water.

Do not charge for any transportation furnished to any person employed on the project.

The provisions apply where work is performed by piece work, station work, etc. The minimum wage paid will be exclusive of equipment rental on any shipment which the worker or subcontractor may furnish in connection with his work.

Take responsibility for carrying out the requirements of this specification and ensure that each subcontractor working on the project complies with its provisions.

Any form of subterfuge, coercion or deduction designated to evade, reduce or discount the established minimum wage scales will be considered a violation of the Contract.

The Fair Labor Standards Acts (FLSA) established one and one-half (1-1/2) pay for overtime in excess of 40 hours worked in 1 week. Do not consider time consumed by the worker in going to and returning from the place of work as part of the hours of work. Do not require or permit any worker to work in excess of 40 hours in 1 week, unless the worker receives compensation at a rate not less than 1-1/2 times the basic rate of pay for all hours worked in excess of 40 hours in the workweek.

The general rates of per diem wages prevailing in this locality for each class and type of workers whose services are considered necessary to fulfill the Contract are indicated in the special provisions, and these rates govern as minimum wage rates on this Contract. A penalty of $60.00 per calendar day or portion of a calendar day for each worker that is paid less than the stipulated general rates of per diem wages for any work done under the Contract will be deducted. The Department, upon receipt of a complaint by a worker,

will determine within 30 days whether good cause exists to believe that the Contractor or a subcontractor has violated wage rate requirements and notify the parties involved of the findings. Make every effort to resolve the alleged violation within 14 days after notification. The next alternative is submittal to binding arbitration in accordance with the provisions of the Texas General Arbitration Act (Art. 224 et seq., Revised Statutes).

Notwithstanding any other provision of the Contract, covenant and agree that the Contractor and its subcontractors will pay each of their employees and contract labor engaged in any way in work under the Contract, a wage not less than what is generally known as the “federal minimum wage” as set out in 29 U.S.C. 206 as that Statute may be amended from time to time.

Pay any worker employed whose position is not listed in the Contract, a wage not less than the per diem wage rate established in the Contract for a worker whose duties are most nearly comparable.

3. RECORD AND INSPECTIONS

Keep copies of weekly payrolls for review. Require subcontractors to keep copies of weekly payrolls for review. Show the name, occupation, number of hours worked each day and per diem wage paid each worker together with a complete record of all deductions made from such wages. Keep records for a period of 3 years from the date of completion of the Contract.

Where the piece-work method is used, indicate on the payroll for each person involved:

- Quantity of piece work performed.
- Price paid per piece-work unit.
- Total hours employed.

The Engineer may require the Contractor to file an affidavit for each payroll certifying that payroll is a true and accurate report of the full wages due and paid to each person employed.

Post or make available to employees the prevailing wage rates from the Contract. Require subcontractors to post or make available to employees the prevailing wage rates from the Contract.

The wage rates listed herein are those predetermined by the Secretary of Labor and State Statue and listed in the United States Department of Labor's (USDOL) General Decisions dated 01-05-2024 and are the minimum wages to be paid accordingly for each specified classification. To determine the applicable wage rate zone, a list entitled "TEXAS COUNTIES IDENTIFIED BY WAGE RATE ZONES" is provided in the contract. Any wage rate that is not listed herein and not in the USDOL's general decision, must be requested by the contractor through the completion of an Additional Classification and Wage Rate Request and be submitted for approval. IMPORTANT NOTICE FOR STATE PROJECTS: only the controlling wage rate zone applies to the contract. Effective 01-05-2024.

CLASS. #	CLASSIFICATION DESCRIPTION	ZONE TX02 *(TX20240002)	ZONE TX03 *(TX20240003)	ZONE TX04 *(TX20240004)	ZONE TX05 *(TX20240005)	ZONE TX06 *(TX20240006)	ZONE TX07 *(TX20240007)	ZONE TX08 *(TX20240008)	ZONE TX24 *(TX20240024)	ZONE TX25 *(TX20240025)	ZONE TX27 *(TX20240027)	ZONE TX28 *(TX20240028)	ZONE TX29 *(TX20240029)	ZONE TX30 *(TX20240030)	ZONE TX37 *(TX20240037)	ZONE TX38 *(TX20240038)	ZONE TX42 *(TX20240042)
1428	Agricultural Tractor Operator						$12.69					$12.35			$11.75		
1300	Asphalt Distributor Operator	$14.87	$13.48	$13.88	$15.72	$15.58	$15.55	$15.72	$13.28	$15.32	$15.62	$14.36	$14.25	$14.03	$13.75	$14.06	$14.40
1303	Asphalt Paving Machine Operator	$13.40	$12.25	$12.35	$13.87	$14.05	$14.36	$14.20	$13.26	$13.99	$14.68	$12.92	$13.44	$12.53	$14.00	$14.32	$12.99
1106	Asphalt Raker	$12.28	$10.61	$12.02	$14.21	$11.65	$12.12	$11.64	$11.44	$12.69	$12.05	$11.34	$11.67	$11.40	$12.59	$12.36	$11.78
1112	Batching Plant Operator, Asphalt																
1115	Batching Plant Operator, Concrete																
1214	Blaster																
1615	Boom Truck Operator						$18.36										
1444	Boring Machine Operator																
1305	Broom or Sweeper Operator	$11.21	$10.33	$10.08	$11.99		$11.04	$11.62		$11.74	$11.41	$10.30		$10.23	$10.60	$12.68	$11.05
1144	Communications Cable Installer																
1124	Concrete Finisher, Paving and Structures	$13.55	$12.46	$13.16	$12.85	$12.64	$12.56	$12.77	$12.44	$14.12	$13.04	$13.38	$12.64	$12.80	$12.79	$12.98	$13.32
1318	Concrete Pavement Finishing Machine Operator				$16.05		$15.48			$16.05		$19.31				$13.07	
1315	Concrete Paving, Curing, Float, Texturing Machine Operator											$16.34				$11.71	
1333	Concrete Saw Operator				$14.67					$14.48	$17.33					$13.99	
1399	Concrete/Gunite Pump Operator																
1344	Crane Operator, Hydraulic 80 tons or less				$18.22		$18.36			$18.12	$18.04	$20.21			$18.63	$13.86	
1345	Crane Operator, Hydraulic Over 80 Tons																
1342	Crane Operator, Lattice Boom 80 Tons or Less	$16.82	$14.39	$13.85	$17.27		$15.87			$17.27		$14.67			$16.42	$14.97	$13.87
1343	Crane Operator, Lattice Boom Over 80 Tons				$20.52		$19.38			$20.52		$17.49			$25.13	$15.80	
1306	Crawler Tractor Operator	$13.96	$16.63	$13.62	$14.26		$15.67			$14.07	$13.15	$13.38			$14.60	$13.68	$13.50
1351	Crusher or Screen Plant Operator																
1446	Directional Drilling Locator						$11.67										
1445	Directional Drilling Operator				$20.32		$17.24										
1139	Electrician	$20.96		$19.87	$19.80		$26.35		$20.27	$19.80		$20.92				$27.11	$19.87
1347	Excavator Operator, 50,000 pounds or less	$13.46	$12.56	$13.67	$17.19		$12.88	$14.38	$13.49	$17.19		$13.88			$14.09	$12.71	$14.42
1348	Excavator Operator, Over 50,000 pounds		$15.23	$13.52	$17.04		$17.71			$16.99	$18.80	$16.22				$14.53	$13.52
1150	Flagger	$9.30	$9.10	$8.50	$10.28	$8.81	$9.45	$8.70		$10.06	$9.71	$9.03	$8.81	$9.08	$9.90	$10.33	$8.10
1151	Form Builder/Setter, Structures	$13.52	$12.30	$13.38	$12.91	$12.71	$12.87	$12.38	$12.26	$13.84	$12.98	$13.07	$13.61	$12.82	$14.73	$12.23	$12.25
1160	Form Setter, Paving & Curb	$12.36	$12.16	$13.93	$11.83	$10.71	$12.94			$13.16	$12.54	$11.33	$10.69		$13.33	$12.34	$13.93
1360	Foundation Drill Operator, Crawler Mounted				$17.99					$17.99						$17.43	
1363	Foundation Drill Operator, Truck Mounted		$16.86	$22.05	$21.51		$16.93			$21.07	$20.20	$20.76		$17.54	$21.39	$15.89	$22.05
1369	Front End Loader Operator, 3 CY or Less	$12.28	$13.49	$13.40	$13.85		$13.04	$13.15	$13.29	$13.69	$12.64	$12.89			$13.51	$13.32	$12.17
1372	Front End Loader Operator, Over 3 CY	$12.77	$13.69	$12.33	$14.96		$13.21	$12.86	$13.57	$14.72	$13.75	$12.32			$13.19	$13.17	$13.02
1329	Joint Sealer																
1172	Laborer, Common	$10.30	$9.86	$10.08	$10.51	$10.71	$10.50	$10.24	$10.58	$10.72	$10.45	$10.30	$10.25	$10.03	$10.54	$11.02	$10.15
1175	Laborer, Utility	$11.80	$11.53	$12.70	$12.17	$11.81	$12.27	$12.11	$11.33	$12.32	$11.80	$11.53	$11.23	$11.50	$11.95	$11.73	$12.37
1346	Loader/Backhoe Operator	$14.18	$12.77	$12.97	$15.68		$14.12			$15.18	$13.58	$12.87		$13.21	$14.13	$14.29	$12.90
1187	Mechanic	$20.14	$15.47	$17.47	$17.74	$17.00	$17.10			$17.68	$18.94	$18.58	$17.00	$16.61	$18.46	$16.96	$17.47

CLASS. #	CLASSIFICATION DESCRIPTION	ZONE TX02 *(TX20240002)	ZONE TX03 *(TX20240003)	ZONE TX04 *(TX20240004)	ZONE TX05 *(TX20240005)	ZONE TX06 *(TX20240006)	ZONE TX07 *(TX20240007)	ZONE TX08 *(TX20240008)	ZONE TX24 *(TX20240024)	ZONE TX25 *(TX20240025)	ZONE TX27 *(TX20240027)	ZONE TX28 *(TX20240028)	ZONE TX29 *(TX20240029)	ZONE TX30 *(TX20240030)	ZONE TX37 *(TX20240037)	ZONE TX38 *(TX20240038)	ZONE TX42 *(TX20240042)
1380	Milling Machine Operator	$15.54	$14.64	$12.22	$14.29		$14.18			$14.32	$14.35	$12.86			$14.75	$13.53	$12.80
1390	Motor Grader Operator, Fine Grade	$17.49	$16.52	$16.88	$17.12	$18.37	$18.51	$16.69	$16.13	$17.19	$18.35	$17.07	$17.74	$17.47	$17.08	$15.69	$20.01
1393	Motor Grader Operator, Rough	$16.15	$14.62	$15.83	$16.20	$17.07	$14.63	$18.50		$16.02	$16.44	$15.12	$16.85	$14.47	$17.39	$14.23	$15.53
1413	Off Road Hauler			$10.08	$12.26		$11.88			$12.25		$12.23			$13.00	$14.60	
1196	Painter, Structures					$21.29	$18.34						$21.29			$18.62	
1396	Pavement Marking Machine Operator	$16.42		$13.10	$13.55		$19.17	$12.01		$13.63	$14.60	$13.17		$16.65	$10.54	$11.18	$13.10
1443	Percussion or Rotary Drill Operator																
1202	Piledriver															$14.95	
1205	Pipelayer		$11.87	$14.64	$13.17	$11.17	$12.79		$11.37	$13.24	$12.66	$13.24	$11.17	$11.67		$12.12	$14.64
1384	Reclaimer/Pulverizer Operator	$12.85			$11.90		$12.88			$11.01		$10.46					
1500	Reinforcing Steel Worker	$13.50	$14.07	$17.53	$16.17		$14.00			$16.18	$12.74	$15.83		$17.10		$15.15	$17.72
1402	Roller Operator, Asphalt	$10.95		$11.96	$13.29		$12.78	$11.61		$13.08	$12.36	$11.68			$11.71	$11.95	$11.50
1405	Roller Operator, Other	$10.36		$10.44	$11.82		$10.50	$11.64		$11.51	$10.59	$10.30		$12.04	$12.85	$11.57	$10.66
1411	Scraper Operator	$10.61	$11.07	$10.85	$12.88		$12.27		$11.12	$12.96	$11.88	$12.43		$11.22	$13.95	$13.47	$10.89
1417	Self-Propelled Hammer Operator																
1194	Servicer	$13.98	$12.34	$14.11	$14.74		$14.51	$15.56	$13.44	$14.58	$14.31	$13.83		$12.43	$13.72	$13.97	$14.11
1513	Sign Erector																
1708	Slurry Seal or Micro-Surfacing Machine Operator																
1341	Small Slipform Machine Operator									$15.96							
1515	Spreader Box Operator	$12.60		$13.12	$14.71		$14.04			$14.73	$13.84	$13.68		$13.45	$11.83	$13.58	$14.05
1705	Structural Steel Welder															$12.85	
1509	Structural Steel Worker						$19.29									$14.39	
1339	Subgrade Trimmer																
1143	Telecommunication Technician																
1145	Traffic Signal/Light Pole Worker						$16.00										
1440	Trenching Machine Operator, Heavy						$18.48										
1437	Trenching Machine Operator, Light																
1609	Truck Driver Lowboy-Float	$14.46	$13.63	$13.41	$15.00	$15.93	$15.66			$16.24	$16.39	$14.30	$16.62	$15.63	$14.28	$16.03	$13.41
1612	Truck Driver Transit-Mix				$14.14					$14.14							
1600	Truck Driver, Single Axle	$12.74	$10.82	$10.75	$13.04	$11.61	$11.79	$13.53	$13.16	$12.31	$13.40	$10.30	$11.61		$11.97	$11.46	$10.75
1606	Truck Driver, Single or Tandem Axle Dump Truck	$11.33	$14.53	$11.95	$12.95		$11.68		$14.06	$12.62	$11.45	$12.28		$13.08	$11.68	$11.48	$11.10
1607	Truck Driver, Tandem Axle Tractor withSemi Trailer	$12.49	$12.12	$12.50	$13.42		$12.81	$13.16		$12.86	$16.22	$12.50			$13.80	$12.27	$12.50
1441	Tunneling Machine Operator, Heavy																
1442	Tunneling Machine Operator, Light																
1706	Welder		$14.02		$14.86		$15.97		$13.74	$14.84					$13.78		
1520	Work Zone Barricade Servicer	$10.30	$12.88	$11.46	$11.70	$11.57	$11.85	$10.77		$11.68	$12.20	$11.22	$11.51	$12.96	$10.54	$11.67	$11.76

Notes:

*Represents the USDOL wage decision.

Any worker employed on this project shall be paid at the rate of one and one half (1-1/2) times the regular rate for every hour worked in excess of forty (40) hours per week.

For reference, the titles and descriptions for the classifications listed here are detailed further in the AGC of Texas' *Standard Job Classifications and Descriptions for Highway, Heavy, Utilities, and Industrial Construction in Texas* posted on the AGC's Web site for any contractor.

TEXAS COUNTIES IDENTIFIED BY
WAGE RATE ZONES: 2, 3, 4, 5, 6, 7, 8, 24, 25, 27, 28, 29, 30, 37, 38, 42

County Name	Zone	County Name	Zone	County Name	Zone	County Name	Zone
Anderson	28	Donley	37	Karnes	27	Reagan	37
Andrews	37	Duval	30	Kaufman	25	Real	37
Angelina	28	Eastland	37	Kendall	7	Red River	28
Aransas	29	Ector	2	Kenedy	30	Reeves	8
Archer	25	Edwards	8	Kent	37	Refugio	27
Armstrong	2	El Paso	24	Kerr	27	Roberts	37
Atascosa	7	Ellis	25	Kimble	37	Robertson	7
Austin	38	Erath	28	King	37	Rockwall	25
Bailey	37	Falls	28	Kinney	8	Runnels	37
Bandera	7	Fannin	28	Kleberg	27	Rusk	4
Bastrop	7	Fayette	27	Knox	37	Sabine	28
Baylor	37	Fisher	37	Lamar	28	San Augustine	28
Bee	27	Floyd	37	Lamb	37	San Jacinto	38
Bell	7	Foard	37	Lampasas	7	San Patricio	29
Bexar	7	Fort Bend	38	LaSalle	30	San Saba	37
Blanco	27	Franklin	28	Lavaca	27	Schleicher	37
Borden	37	Freestone	28	Lee	27	Scurry	37
Bosque	28	Frio	27	Leon	28	Shackelford	37
Bowie	4	Gaines	37	Liberty	38	Shelby	28
Brazoria	38	Galveston	38	Limestone	28	Sherman	37
Brazos	7	Garza	37	Lipscomb	37	Smith	4
Brewster	8	Gillespie	27	Live Oak	27	Somervell	28
Briscoe	37	Glasscock	37	Llano	27	Starr	30
Brooks	30	Goliad	29	Loving	37	Stephens	37
Brown	37	Gonzales	27	Lubbock	2	Sterling	37
Burleson	7	Gray	37	Lynn	37	Stonewall	37
Burnet	27	Grayson	25	Madison	28	Sutton	8
Caldwell	7	Gregg	4	Marion	28	Swisher	37
Calhoun	29	Grimes	28	Martin	37	Tarrant	25
Callahan	25	Guadalupe	7	Mason	27	Taylor	2
Cameron	3	Hale	37	Matagorda	27	Terrell	8
Camp	28	Hall	37	Maverick	30	Terry	37
Carson	2	Hamilton	28	McCulloch	37	Throckmorton	37
Cass	28	Hansford	37	McLennan	7	Titus	28
Castro	37	Hardeman	37	McMullen	30	Tom Green	2
Chambers	38	Hardin	38	Medina	7	Travis	7
Cherokee	28	Harris	38	Menard	37	Trinity	28
Childress	37	Harrison	42	Midland	2	Tyler	28
Clay	25	Hartley	37	Milam	28	Upshur	4
Cochran	37	Haskell	37	Mills	37	Upton	37
Coke	37	Hays	7	Mitchell	37	Uvalde	30
Coleman	37	Hemphill	37	Montague	37	Val Verde	8
Collin	25	Henderson	28	Montgomery	38	Van Zandt	28
Collingsworth	37	Hidalgo	3	Moore	37	Victoria	6
Colorado	27	Hill	28	Morris	28	Walker	28
Comal	7	Hockley	37	Motley	37	Waller	38
Comanche	37	Hood	28	Nacogdoches	28	Ward	37
Concho	37	Hopkins	28	Navarro	28	Washington	28
Cooke	37	Houston	28	Newton	28	Webb	3
Coryell	7	Howard	37	Nolan	37	Wharton	27
Cottle	37	Hudspeth	8	Nueces	29	Wheeler	37
Crane	37	Hunt	25	Ochiltree	37	Wichita	5
Crockett	8	Hutchinson	37	Oldham	37	Wilbarger	37
Crosby	2	Irion	2	Orange	38	Willacy	30
Culberson	8	Jack	28	Palo Pinto	28	Williamson	7
Dallam	37	Jackson	27	Panola	28	Wilson	7
Dallas	25	Jasper	28	Parker	25	Winkler	37
Dawson	37	Jeff Davis	8	Parmer	37	Wise	25
Deaf Smith	37	Jefferson	38	Pecos	8	Wood	28
Delta	25	Jim Hogg	30	Polk	28	Yoakum	37
Denton	25	Jim Wells	27	Potter	2	Young	37
DeWitt	27	Johnson	25	Presidio	8	Zapata	30
Dickens	37	Jones	25	Rains	28	Zavala	30
Dimmit	30			Randall	2		

01/05/2024

Special Provision to Item 000
Nondiscrimination

1. DESCRIPTION

All recipients of federal financial assistance are required to comply with various nondiscrimination laws including Title VI of the Civil Rights Act of 1964, as amended, (Title VI). Title VI forbids discrimination against anyone in the United States on the grounds of race, color, or national origin by any agency receiving federal funds.

Texas Department of Transportation, as a recipient of Federal financial assistance, and under Title VI and related statutes, ensures that no person shall on the grounds of race, religion (where the primary objective of the financial assistance is to provide employment per 42 U.S.C. § 2000d-3), color, national origin, sex, age or disability be excluded from participation in, be denied the benefits of, or otherwise be subjected to discrimination under any Department programs or activities.

2. DEFINITION OF TERMS

Where the term “contractor” appears in the following six nondiscrimination clauses, the term “contractor” is understood to include all parties to contracts or agreements with the Texas Department of Transportation.

3. NONDISCRIMINATION PROVISIONS

During the performance of this contract, the contractor agrees as follows:

3.1. **Compliance with Regulations**. The Contractor shall comply with the Regulations relative to nondiscrimination in Federally-assisted programs of the Department of Transportation (hereinafter, “DOT”) Title 49, Code of Federal Regulations, Part 21, as they may be amended from time to time, (hereinafter referred to as the Regulations), which are herein incorporated by reference and made a part of this contract.

3.2. **Nondiscrimination**. The contractor, with regard to the work performed by it during the contract, shall not discriminate on the grounds of race, color, or national origin in the selection and retention of subcontractors, including procurements of materials and leases of equipment. The contractor shall not participate either directly or indirectly in the discrimination prohibited by section 21.5 of the Regulations, including employment practices when the contract covers a program set forth in Appendix B of the Regulations.

3.3. **Solicitations for Subcontracts, Including Procurements of Materials and Equipment:** In all solicitations either by competitive bidding or negotiation made by the contractor for work to be performed under a subcontract, including procurements of materials or leases of equipment, each potential subcontractor or supplier shall be notified by the contractor of the contractor's obligations under this contract and the Regulations relative to nondiscrimination on the grounds of race, color, or national origin.

3.4. **Information and Reports:** The contractor shall provide all information and reports required by the Regulations or directives issued pursuant thereto, and shall permit access to its books, records, accounts, other sources of information, and its facilities as may be determined by the Recipient or the Texas Department of Transportation to be pertinent to ascertain compliance with such Regulations, orders and instructions. Where any information required of a contractor is in the exclusive possession of another who fails or refuses to furnish this information the contractor shall so certify to the Recipient, or the Texas Department of Transportation as appropriate, and shall set forth what efforts it has made to obtain the information.

3.5. **Sanctions for Noncompliance**. In the event of the contractor's noncompliance with the nondiscrimination provisions of this contract, the Recipient shall impose such contract sanctions as it or the Texas Department of Transportation may determine to be appropriate, including, but not limited to:

- withholding of payments to the contractor under the contract until the contractor complies, and/or
- cancellation, termination or suspension of the contract, in whole or in part.

3.6. **Incorporation of Provisions**. The contractor shall include the provisions of paragraphs (1) through (6) in every subcontract, including procurements of materials and leases of equipment, unless exempt by the Regulations, or directives issued pursuant thereto. The contractor shall take such action with respect to any subcontract or procurement as the Recipient or the Texas Department of Transportation may direct as a means of enforcing such provisions including sanctions for non-compliance: Provided, however, that, in the event a contractor becomes involved in, or is threatened with, litigation with a subcontractor or supplier as a result of such direction, the contractor may request the Recipient to enter into such litigation to protect the interests of the Recipient, and, in addition, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

Special Provision to Item 000
Small Business Enterprise in State Funded Projects

1. DESCRIPTION

The purpose of this Special Provision is to carry out the Texas Department of Transportation's policy of ensuring that Small Business Enterprise (SBE) has an opportunity to participate in the performance of contracts. If the SBE goal is greater than zero, Article A of this Special Provision shall apply to this Contract; otherwise, Article B of this Special Provision applies. The percentage goal for SBE participation in the work to be performed under this contract will be shown in the proposal.

2. DEFINITIONS

Small Business Enterprise (SBE) is a firm (including affiliates) certified by the Department whose annual gross receipts do not exceed the U.S. Small Business Administration's size standards for 4 consecutive years. Firms certified as Historically Underutilized Businesses (HUBs) by the Texas Comptroller of Public Accounts and as Disadvantaged Business Enterprises (DBEs) by the Texas Uniform Certification Program automatically qualify as SBEs.

2.1. **Article A - SBE Goal is Greater than Zero.**

2.1.1. **Policy**. The Department is committed to providing contracting opportunities for small businesses. In this regard, it is the Department's policy to develop and maintain a program in order to facilitate contracting opportunities for small businesses. Consequently, the requirements of the Department's Small Business Enterprise Program apply to this contract as follows:

2.1.1.1. The Contractor shall make a good faith effort to meet the SBE goal for this contract.

2.1.1.2. The Contractor and any Subcontractors shall not discriminate on the basis of race, color, national origin, age, disability or sex in the award and performance of this contract. These nondiscrimination requirements shall be incorporated into any subcontract and purchase order.

2.1.1.3. After a conditional award is made to the low bidder, the Department will determine the adequacy of a Contractor's efforts to meet the contract goal, as is outlined under Section 2, "Contractor's Responsibilities." If the requirements of Section 2 are met, the contract will be forwarded to the Contractor for execution.

The Contractor's performance, during the construction period of the contract in meeting the SBE goal, will be monitored by the Department.

2.1.2. **Contractor's Responsibilities**. These requirements must be satisfied by the Contractor. A SBE Contractor may satisfy the SBE requirements by performing at least 25% of the contract work with its own organization as defined elsewhere in the contract.

2.1.2.1. The Contractor shall submit a completed SBE Commitment Agreement Form for each SBE they intend to use to satisfy the SBE goal so as to arrive in the Department's Office of Civil Rights (OCR) in Austin, Texas not later than 5:00 p.m. on the 10th business day, excluding national holidays, after the conditional award of the contract. When requested, additional time, not to exceed 7 business days, excluding national holidays, may be granted based on documentation submitted by the Contractor.

2.1.2.2. A Contractor who cannot meet the contract goal, in whole or in part, shall document the good faith efforts taken to meet the SBE goal. The Department will consider as good faith efforts all documented explanations

that are submitted and that describe a Contractor's failure to meet a SBE goal or obtain SBE participation, including:

2.1.2.2.1. Advertising in general circulation, trade association, and/or minority/women focus media concerning subcontracting opportunities,

2.1.2.2.2. Dividing the contract work into reasonable portions in accordance with standard industry practices,

2.1.2.2.3. Documenting reasons for rejection or meeting with the rejected SBE to discuss the rejection,

2.1.2.2.4. Providing qualified SBEs with adequate information about bonding, insurance, plans, specifications, scope of work, and the requirements of the contract,

2.1.2.2.5. Negotiating in good faith with qualified SBEs, not rejecting qualified SBEs who are also the lowest responsive bidder, and;

2.1.2.2.6. Using the services of available minorities and women, community organizations, contractor groups, local, state and federal business assistance offices, and other organizations that provide support services to SBEs.

2.1.2.3. The good faith effort documentation is due at the time and place specified in Subarticle 2.(a). of this Special Provision. The Director of the DBE & SBE Programs Section will evaluate the Contractor's documentation. If it is determined that the Contractor has failed to meet the good faith effort requirements, the Contractor will be given an opportunity for reconsideration by the Department.

2.1.2.4. Should the bidder to whom the contract is conditionally awarded refuse, neglect or fail to meet the SBE goal and/or demonstrate to the Department's satisfaction sufficient efforts to obtain SBE participation, the proposal guaranty filed with the bid shall become the property of the State, not as a penalty, but as liquidated damages to the Department.

2.1.2.5. The Contractor must not terminate a SBE subcontractor submitted on a commitment agreement for a contract with an assigned goal without the prior written consent of the Department.

2.1.2.6. The Contractor shall designate a SBE contact person who will administer the Contractor's SBE program and who will be responsible for submitting reports, maintaining records, and documenting good faith efforts to use SBEs.

2.1.2.7. The Contractor must inform the Department of the representative's name, title and telephone number within 10 days of beginning work.

2.1.3. **Eligibility of SBEs.**

2.1.3.1. The Department certifies the eligibility of SBEs.

2.1.3.2. The Department maintains and makes available to interested parties a directory of certified SBEs.

2.1.3.3. Only firms certified at the time of letting or at the time the commitments are submitted are eligible to be used in the information furnished by the Contractor required under Section 2.(a) above.

2.1.3.4. Certified HUBs and DBEs are eligible as SBEs.

2.1.3.5. Small Business Size Regulations and Eligibility is referenced on e-CFR (Code of Federal Regulations), Title 13 – Business Credit and Assistance, Chapter 1 – Small Business Administration, Part 121 – Small Business Size Regulations, Subpart A – Size Eligibility Provisions and Standards.

2.1.4. **Determination of SBE Participation**. SBE participation shall be counted toward meeting the SBE goal in this contract in accordance with the following:

2.1.4.1. A Contractor will receive credit for all payments actually made to a SBE for work performed and costs incurred in accordance with the contract, including all subcontracted work.

2.1.4.2. A SBE Contractor or subcontractor may not subcontract more than 75% of a contract. The SBE shall perform not less than 25% of the value of the contract work with its own organization.

2.1.4.3. A SBE may lease equipment consistent with standard industry practice. A SBE may lease equipment from the prime contractor if a rental agreement, separate from the subcontract specifying the terms of the lease arrangement, is approved by the Department prior to the SBE starting the work in accordance with the following:

2.1.4.3.1. If the equipment is of a specialized nature, the lease may include the operator. If the practice is generally acceptable with the industry, the operator may remain on the lessor's payroll. The operator of the equipment shall be subject to the full control of the SBE, for a short term, and involve a specialized piece of heavy equipment readily available at the job site.

2.1.4.3.2. For equipment that is not specialized, the SBE shall provide the operator and be responsible for all payroll and labor compliance requirements.

2.1.5. **Records and Reports**.

2.1.5.1. The Contractor shall submit monthly reports, after work begins, on SBE payments, (including payments to HUBs and DBEs). The monthly reports are to be sent to the Area Engineer's office. These reports will be due within 15 days after the end of a calendar month.

These reports will be required until all SBE subcontracting or supply activity is completed. The "SBE Progress Report" is to be used for monthly reporting. Upon completion of the contract and prior to receiving the final payment, the Contractor shall submit the "SBE Final Report" to the Office of Civil Rights and a copy to the Area Engineer. These forms may be obtained from the Office of Civil Rights and reproduced as necessary. The Department may verify the amounts being reported as paid to SBEs by requesting, on a random basis, copies of invoices and cancelled checks paid to SBEs. When the SBE goal requirement is not met, documentation supporting Good Faith Efforts, as outlined in Section 2.(b) of this Special Provision, must be submitted with the Final Report.

2.1.5.2. SBE subcontractors and/or suppliers should be identified on the monthly report by SBE certification number, name and the amount of actual payment made to each during the monthly period. **These reports are required regardless of whether or not SBE activity has occurred in the monthly reporting period.**

2.1.5.3. All such records must be retained for a period of 3 years following completion of the contract work and shall be available at reasonable times and places for inspection by authorized representatives of the Department.

2.1.6. **Compliance of Contractor**. To ensure that SBE requirements of this contract are complied with, the Department will monitor the Contractor's efforts to involve SBEs during the performance of this contract. This will be accomplished by a review of monthly reports submitted by the Contractor indicating his progress in achieving the SBE contract goal and by compliance reviews conducted by the Department.

A Contractor's failure to comply with the requirements of this Special Provision shall constitute a material breach of this contract. In such a case, the Department reserves the right to employ remedies as the Department deems appropriate in the terms of the contract.

2.2. **Article B - No SBE Goal**.

2.2.1. **Policy**. It is the policy of the Department that SBEs shall have an opportunity to participate in the performance of contracts. Consequently, the requirements of the Department's Small Business Enterprise Program apply to this contract as specified in Section 2-5 of this Article.

2.2.2. **Contractor's Responsibilities**. If there is no SBE goal, the Contractor will offer SBEs an opportunity to participate in the performance of contracts and subcontracts.

2.2.3. **Prohibit Discrimination**. The Contractor and any subcontractor shall not discriminate on the basis of race, color, national origin, religion, age, disability or sex in the award and performance of contracts. These nondiscrimination requirements shall be incorporated into any subcontract and purchase order.

2.2.4. **Records and Reports**.

2.2.4.1. The Contractor shall submit reports on SBE (including HUB and DBE) payments. The reports are to be sent to the Area Engineer's office. These reports will be due annually by the 31st of August or at project completion, whichever comes first.

These reports will be required until all SBE subcontracting or supply activity is completed. The "SBE Progress Report" is to be used for reporting. Upon completion of the contract and prior to receiving the final payment, the Contractor shall submit the "SBE Final Report" to the Office of Civil Rights and a copy to the Area Engineer. These forms may be obtained from the Office of Civil Rights and reproduced as necessary. The Department may verify the amounts being reported as paid to SBEs by requesting copies of invoices and cancelled checks paid to SBEs on a random basis.

2.2.4.2. SBE subcontractors and/or suppliers should be identified on the report by SBE Certification Number, name and the amount of actual payment made.

2.2.4.3. All such records must be retained for a period of 3 years following completion of the contract work and shall be available at reasonable times and places for inspection by authorized representatives of the Department.

Special Provision 000
Important Notice to Contractors

For Dollar Amount of Original Contract		Dollar Amount of Daily Contract Administration Liquidated Damages per Working Day
From More Than	To and including	
0	1,000,000	618
1,000,000	3,000,000	832
3,000,000	5,000,000	940
5,000,000	15,000,000	1317
15,000,000	25,000,000	1718
25,000,000	50,000,000	2411
50,000,000	Over 50,000,000	4265

In addition to the amount shown in Table 1, the Liquidated Damages will be increased by the amount shown in Item 8 of the General Notes for Road User Cost (RUC), when applicable.

Special Provision 000
Certificate of Interested Parties (Form 1295)

Submit Form 1295, "Certificate of Interested Parties," in the following instances:

- at Contract execution for Contracts awarded by the Commission;
- at Contract execution for Contracts awarded by the District Engineer or Chief Engineer with an award amount of $1,000,000 or more; at any time an existing Contract awarded by the District Engineer or Chief Engineer increases in value to $1,000,000 or more due to changes in the Contract; at any time there is an increase of $1,000,000 or more to an existing Contract (change orders, extensions, and renewals); or
- at any time there is a change to the information in Form 1295, when the form was filed for an existing Contract.

Form 1295 and instructions on completing and filing the form are available on the Texas Ethics Commission website.

Special Provision 000
Notice of Contractor Performance Evaluations

1. GENERAL

In accordance with Texas Transportation Code §223.012, the Engineer will evaluate Contractor performance based on quality, safety, and timeliness of the project.

2. DEFINITIONS

2.1. **Project Recovery Plan (PRP)**—a formal, enforceable plan developed by the Contractor, in consultation with the District, that documents the cause of noted quality, safety, and timeliness issues and specifies how the Contractor proposes to correct project-specific performance deficiencies.

In accordance with Title 43, Texas Administrative Code (TAC), §9.23, the District will request a PRP if the Contractor's performance on a project is below the Department's acceptable standards and will monitor the Contractor's compliance with the established plan.

2.2. **Corrective Action Plan (CAP)**—a formal, enforceable plan developed by the Contractor, and proposed for adoption by the Construction or Maintenance Division, that documents the cause of noted quality, safety, and timeliness issues and specifies how the Contractor proposes to correct statewide performance deficiencies.

In accordance with 43 TAC §9.23, the Division will request a CAP if the average of the Contractor's statewide final evaluation scores falls below the Department's acceptable standards for the review period and will monitor the Contractor's compliance with the established plan.

3. CONTRACTOR EVALUATIONS

In accordance with Title 43, Texas Administrative Code (TAC) §9.23, the Engineer will schedule evaluations at the following intervals, at minimum:

- Interim evaluations—at or within 30 days after the anniversary of the notice to proceed, for Contracts extending beyond 1 yr., and
- Final evaluation—upon project closeout.

In case of a takeover agreement, neither the Surety nor its performing Contractor will be evaluated.

In addition to regularly scheduled evaluations, the Engineer may schedule an interim evaluation at any time to formally communicate issues with quality, safety, or timeliness. Upon request, work with the Engineer to develop a PRP to document expectations for correcting deficiencies.

Comply with the PRP as directed. Failure to comply with the PRP may result in additional remedial actions available to the Engineer under Item 5, "Control of the Work." Failure to meet a PRP to the Engineer's satisfaction may result in immediate referral to the Performance Review Committee for consideration of further action against the Contractor.

The Engineer will consider and document any events outside the Contractor's control that contributed to the failure to meet performance standards or comply with a PRP, including consideration of sufficient time.

Follow the escalation ladder if there is a disagreement regarding an evaluation or disposition of a PRP. The Contractor may submit additional documentation pertaining to the dispute. The District Engineer's decision

on a Contractor's evaluation score and recommendation of action required in a PRP or follow up for non-compliance is final.

4. DIVISION OVERSIGHT

Upon request of the Construction or Maintenance Division, develop and submit for Division approval a proposed CAP to document expectations for correcting deficiencies in the performance of projects statewide.

Comply with the CAP as directed. The CAP may be modified at any time up to completion or resolution after written approval of the premise of change from the Division. Failure to meet an adopted or revised adopted CAP to the Division's satisfaction within 120 days will result in immediate referral to the Performance Review Committee for consideration of further action against the Contractor.

The Division will consider and document any events outside the Contractor's control that contributed to the failure to meet performance standards or comply with a CAP, including consideration of sufficient time and associated costs as appropriate.

5. PERFORMANCE REVIEW COMMITTEE

The Performance Review Committee, in accordance with 43 TAC §9.24, will review at minimum all final evaluations, history of compliance with PRPs, any adopted CAPs including agreed modifications, any information about events outside a Contractor's control contributing to the Contractor's performance, and any documentation submitted by the Contractor and may recommend one or more of the following actions:

- take no action,
- reduce the Contractor's bidding capacity,
- prohibit the Contractor from bidding on one or more projects,
- immediately suspend the Contractor from bidding for a specified period of time, by reducing the Contractor's bidding capacity to zero, or
- prohibit the Contractor from being awarded a Contract on which they are the apparent low bidder.

The Deputy Executive Director will determine any further action against the Contractor.

6. APPEALS PROCESS

In accordance with 43 TAC §9.25, the Contractor may appeal remedial actions determined by the Deputy Executive Director.

Special Provision to Item 1
Abbreviations and Definitions

Item 1, "Abbreviations and Definitions," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 1.3.32., "Construction Contract.," is voided and replaced by the following.

3.32. **Construction Contract**. A Contract entered under Transportation Code, Chapter 223, Subchapter A, for the construction, reconstruction, repair, or maintenance of a segment of the State highway system.

Section 1.3.62., "Highway, Street, or Road.," is voided and replaced by the following.

3.62. **Highway, Street, or Road**. General terms denoting a public way for purposes of and related to vehicular, pedestrian, and bicycle travel, including the entire area within the right of way including Intersections and Easements; all related structures, improvements, and appurtenances, including but not limited to the roadside and roadside facilities, drainage systems, signal systems, and other traffic in formation and control systems; or other structures or improvements that directly or indirectly serve public travel. Recommended usage in urban areas is "highway" or "street," and in rural areas, "highway" or "road."

Section 1.3.68., "Intersection.," is voided and replaced by the following.

3.68. **Intersection**. The general area where two or more highways, streets, or roads join or cross, including the roadway and roadside facilities for vehicular, pedestrian, and bicycle traffic movements within it.

Section 1.3.111., "Repair.," is added.

3.111. **Repair**. Performed under Transportation Code §223, Subchapter A for Highway Improvement Contracts and includes restoration of a Highway, Street, or Road by replacing or putting together, in whole or in part, what is torn, broken, or otherwise damaged. "Repair" denotes the process of restoring all or part of a Highway, Street, or Road that has been subjected to decay, waste, injury, partial destruction, erosion, dilapidation, degradation, etc. "Repair" includes work in Construction and Routine Maintenance Contracts.

Section 1.3.118., "Routine Maintenance Contract.," is voided and replaced by the following.

3.118. **Routine Maintenance Contract**. A maintenance Contract entered under Transportation Code, Chapter 223, Subchapter A for Highway Improvement Contracts and let through and executed as a result of the routine maintenance contracting procedure to preserve and repair roadways, bridges, and rights of way, with all its components to its designed or accepted configuration.

Special Provision to Item 2
Instructions to Bidders

Item 2, "Instructions to Bidders" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 3., "Issuing Proposal Forms," is supplemented by the following:

The Electronic State Business Daily (ESBD), the Integrated Contractor Exchange (iCX) system, and the project proposal are the official sources of advertisement and bidding information for the State and Local Lettings. Bidders should bid the project using the information found therein, including any addenda. These sources take precedence over information from other sources, including TxDOT webpages, which are unofficial and intended for informational purposes only.

Special Provision to Item 2
Instructions to Bidders

Item 2, "Instructions to Bidders," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 2.8.2., "Proposal Guaranty," third paragraph is replaced by the following.

It is the Bidder's responsibility to ensure the electronic bid bond is issued in the name or Department vendor identification numbers of the Bidder or Bidders.

Special Provision to Item 2
Instructions to Bidders

Item 2, "Instructions to Bidders," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 2.3., "Issuing Proposal Forms," is supplemented by the following:

- the Bidder or affiliate of the Bidder that was originally determined as the apparent low Bidder on a project but was deemed nonresponsive for failure to register or participate in the Department of Homeland Security's (DHS) E-Verify system as specified in Article 2.15., "Department of Homeland Security (DHS) E-Verify System," is prohibited from rebidding that specific project.

Article 2.7., "Nonresponsive Bid," is supplemented by the following:

- the Bidder failed to participate in the Department of Homeland Security's (DHS) as specified in Article 2.15., "Department of Homeland Security (DHS) E-Verify System."

Article 2.15., "Department of Homeland Security (DHS) E-Verify System," is added.

The Department will not award a Contract to a Contractor that is not registered in the DHS E-Verify system. Remain active in E-Verify throughout the life of the Contract. In addition, in accordance with paragraph six of Article 8.2., "Subcontracting," include this requirement in all subcontracts and require that subcontractors remain active in E-Verify until their work is completed.

If the apparent low Bidder does not appear in the DHS E-Verify system before award, the Contractor must submit documentation showing that they are compliant within 5 calendar days after bid opening. A Contractor that fails to comply or respond within the deadline will be declared nonresponsive. The Bidder forfeiting the proposal guaranty will not be considered in future proposals for the same work unless there has been a substantial change in the scope of the work.

The Department may recommend that the Commission:

- reject all bids, or
- award the Contract to the new apparent low Bidder, if the Department is able to verify the Bidder's participation in the DHS E-Verify system.

If the Department is unable to verify the new apparent low Bidder's participation in the DHS E-Verify system:

- the new apparent low Bidder will not be deemed nonresponsive,
- the new apparent low Bidder's guaranty will not be forfeited,
- the Department will reject all bids,
- the new apparent low Bidder will remain eligible to receive future proposals for the same project, and
- the proposal guaranty of the original low bidder will become the property of the State, not as a penalty, but as liquidated damages.

Special Provision to Item 3
Award and Execution Contract

Item 3, Award and Execution of Contract," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 4.3, "Insurance." The first sentence is voided and replaced by the following:

For construction and building Contracts, submit a certificate of insurance showing coverages in accordance with Contract requirements. For routine maintenance Contracts, refer to Article 8, "Beginning of Work."

Article 8, "Beginning of Work." The first sentence is supplemented by the following:

For a routine maintenance Contract, do not begin work until a certificate of insurance showing coverages in accordance with the Contract requirements is provided and accepted.

Special Provision to Item 3
Award and Execution of Contract

Item 3, "Award and Execution of Contract" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 4.3 "Insurance" is being amended by the following:

Table 2
Insurance Requirements

Type of Insurance	Amount of Coverage
Commercial General Liability Insurance	Not Less Than: $600,000 each occurrence
Business Automobile Policy	Not Less Than: $600,000 combined single limit
Workers' Compensation	Not Less Than: Statutory
All Risk Builder's Risk Insurance (For building-facilities contracts only)	100% of Contract Price

Special Provision to Item 5
Control of the Work

Item 5, "Control of the Work," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 5.1, "Authority of Engineer," is voided and replaced by the following.

The Engineer has the authority to observe, test, inspect, approve, and accept the work. The Engineer decides all questions about the quality and acceptability of materials, work performed, work progress, Contract interpretations, and acceptable Contract fulfillment. The Engineer has the authority to enforce and make effective these decisions.

The Engineer acts as a referee in all questions arising under the terms of the Contract. The Engineer's decisions will be final and binding.

The Engineer will pursue and document actions against the Contractor as warranted to address Contract performance issues. Contract remedies include, but are not limited to, the following:

- conducting interim performance evaluations requiring a Project Recovery Plan, in accordance with Title 43, Texas Administrative Code (TAC) §9.23,
- requiring the Contractor to remove and replace defective work, or reducing payment for defective work,
- removing an individual from the project,
- suspending the work without suspending working day charges,
- assessing standard liquidated damages to recover the Department's administrative costs, including additional project-specific liquidated damages when specified in the Contract in accordance with 43 TAC §9.22,
- withholding estimates,
- declaring the Contractor to be in default of the Contract, and
- in case of a Contractor's failure to meet a Project Recovery Plan, referring the issue directly to the Performance Review Committee for consideration of further action against the Contractor in accordance with 43 TAC §9.24.

The Engineer will consider and document any events outside the Contractor's control that contributed to the failure to meet performance standards, including consideration of sufficient time.

Follow the issue escalation ladder if there is disagreement regarding the application of Contract remedies.

Special Provision to Item 5
Control of the Work

Item 5, “Control of the Work” of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 5.4, “Coordination of Plans, Specifications, and Special Provisions,” the last sentence of the last paragraph is replaced by the following:

Failure to promptly notify the Engineer will constitute a waiver of all contract claims against the Department for misunderstandings or ambiguities that result from the errors, omissions, or discrepancies.

Special Provision to Item 5
Control of the Work

Item 5, "Control of the Work," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 5.1, "Authority of Engineer," is voided and replaced by the following.

The Engineer has the authority to observe, test, inspect, approve, and accept the work (either in writing or orally). The Engineer decides all questions about the quality and acceptability of materials, work performed, work progress, Contract interpretations, applicability of standard details, and acceptable Contract fulfillment. The Engineer has the authority to enforce and make effective these decisions.

- Unless noted elsewhere in the Contract or by the Engineer, payment for Contractor work supports it is in accordance with the Contract requirements at that time. This payment does not eliminate the Contractor's responsibilities for the work as defined in Article 7.17., "Contractor's Responsibility for Work," or Article 5.12., "Final Acceptance."
- The Engineer acts as a referee in all questions arising under the terms of the Contract.
- The Engineer's decisions are final and binding.

The Engineer will pursue and document actions against the Contractor as warranted to address Contract performance issues. Contract remedies include, but are not limited to, the following:

- conducting interim performance evaluations requiring a Project Recovery Plan, in accordance with Title 43, Texas Administrative Code (TAC) §9.23,
- requiring the Contractor to remove and replace defective work, or reducing payment for defective work,
- removing an individual from the project,
- suspending the work without suspending working day charges,
- assessing standard liquidated damages to recover the Department's administrative costs, including additional project-specific liquidated damages when specified in the Contract in accordance with 43 TAC §9.22,
- withholding estimates,
- declaring the Contractor to be in default of the Contract, and
- in case of a Contractor's failure to meet a Project Recovery Plan, referring the issue directly to the Performance Review Committee for consideration of further action against the Contractor in accordance with 43 TAC §9.24.

The Engineer will consider and document any events outside the Contractor's control that contributed to the failure to meet performance standards, including consideration of sufficient time.

Follow the issue escalation ladder if there is disagreement regarding the application of Contract remedies.

Article 5.10, "Inspection," the first paragraph is voided and replaced by the following.

Inspectors are authorized representatives of the Engineer. Inspectors are authorized to examine all work performed and materials furnished, including preparation, fabrication, and material manufacture. Inspectors inform the Contractor of failures to meet Contract requirements. Inspectors may reject work or materials and may suspend work until any issues can be referred to and decided by the Engineer. The Engineer may authorize Inspectors to adjust the traffic control. Inspectors cannot alter, add, or waive Contract provisions, issue instructions contrary to the Contract, act as foremen for the Contractor, or interfere with the management of the work. Inspection or lack of inspection will not relieve the Contractor from obligation to provide materials or perform the work in accordance with the Contract.

Special Provision to Item 6
Control of Materials

For this project, Item 6, "Control of Materials," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Article 4., "Sampling, Testing, and Inspection," is supplemented by the following:

Meet with the Engineer and choose either the Department or a Department-selected Commercial Lab (CL) for conducting the subset of project-level sampling and testing shown in Table 1, "Select Guide Schedule Sampling and Testing." Selection may be made on a test by test basis. CLs will meet the testing turnaround times shown (includes test time and time for travel/sampling and reporting) and in all cases issue test reports as soon as possible.

If the Contractor chooses a Department-selected CL for any Table 1 sampling and testing:

- notify the Engineer, District Lab, and the CL of project scheduling that may require CL testing;
- provide the Engineer, District Lab, and CL at least 24 hours' notice by phone and e-mail;
- reimburse the Department for CL Table 1 testing using the contract fee schedule for the CL (including mileage and travel/standby time) at the minimum guide schedule testing frequencies;
- reimburse the Department for CL Table 1 testing above the minimum guide schedule frequencies for retesting when minimum frequency testing results in failures to meet specification limits;
- agree with the Engineer and CL upon a policy regarding notification for testing services;
- give any cancellation notice to the Engineer, District Lab, and CL by phone and e-mail;
- reimburse the Department a $150 cancellation fee to cover technician time and mileage charges for previously scheduled work cancelled without adequate notice, which resulted in mobilization of technician and/or equipment by the CL; and
- all CL charges will be reimbursed to the Department by a deduction from the Contractor's monthly pay estimate.

If the CL does not meet the Table 1 turnaround times, testing charge to the Contractor will be reduced by 50% for the first late day and an additional 5% for each succeeding late day.

Approved CL project testing above the minimum testing frequencies in the Guide Schedule of Sampling and Testing, and not as the result of failing tests, will be paid by the Department.

Other project-level Guide Schedule sampling and testing not shown on Table 1 will be the responsibility of the Department.

Table 1
Select Guide Schedule Sampling and Testing (Note 1)

TxDOT Test	Test Description	Turn-Around Time (Calendar days)
SOILS/BASE		
Tex-101-E	Preparation of Soil and Flexible Base Materials for Testing (included in other tests)	
Tex-104-E	Liquid Limit of Soils (included in 106-E)	
Tex-105-E	Plastic Limit of Soils (included in 106-E)	
Tex-106-E	Calculating the Plasticity Index of Soils	7
Tex-110-E	Particle Size Analysis of Soils	6
Tex-113-E	Moisture-Density Relationship of Base Materials	7
Tex-114-E	Moisture-Density Relationship of Subgrade and Embankment Soil	7
Tex-115-E	Field Method for In-Place Density of Soils and Base Materials	2
Tex-116-E	Ball Mill Method for the Disintegration of Flexible Base Material	5
Tex-117-E, Part II	Triaxial Compression Tests For Disturbed Soils and Base Materials (Part II)	6
Tex-113-E **w/** Tex-117-E	Moisture-Density Relationship of Base Materials **with** Triaxial Compression Tests For Disturbed Soils and Base Materials (Part II)	10
Tex-140-E	Measuring Thickness of Pavement Layer	2
Tex-145-E	Determining Sulfate Content in Soils - Colorimetric Method	4
HOT MIX ASPHALT		
Tex-200-F	Sieve Analysis of Fine and Coarse Aggregate (dry, from ignition oven with known correction factors)	1 (Note 2)
Tex-203-F	Sand Equivalent Test	3
Tex-206-F, **w/** Tex-207-F, Part I, **w/** Tex-227-F	**(Lab-Molded Density of Production Mixture – Texas Gyratory)** Method of Compacting Test Specimens of Bituminous Mixtures **with** Density of Compacted Bituminous Mixtures, Part I - Bulk Specific Gravity of Compacted Bituminous Mixtures, **with** Theoretical Maximum Specific Gravity of Bituminous Mixtures	1 (Note 2)
Tex-207-F, Part I **&/or** Part VI	**(In-Place Air Voids of Roadway Cores)** Density of Compacted Bituminous Mixtures, Part I- Bulk Specific Gravity of Compacted Bituminous Mixtures **&/or** Part VI - Bulk Specific Gravity of Compacted Bituminous Mixtures Using the Vacuum Method	1 (Note 2)
Tex-207-F, Part V	Density of Compacted Bituminous Mixtures, Part V- Determining Mat Segregation using a Density-Testing Gauge	3
Tex-207-F, Part VII	Density of Compacted Bituminous Mixtures, Part VII - Determining Longitudinal Joint Density using a Density-Testing Gauge	4
Tex-212-F	Moisture Content of Bituminous Mixtures	3
Tex-217-F	Deleterious Material and Decantation Test for Coarse Aggregate	4
Tex-221-F	Sampling Aggregate for Bituminous Mixtures, Surface Treatments, and LRA (included in other tests)	
Tex-222-F	Sampling Bituminous Mixtures (included in other tests)	
Tex-224-F	Determination of Flakiness Index	3
Tex-226-F	Indirect Tensile Strength Test (production mix)	4
Tex-235-F	Determining Draindown Characteristics in Bituminous Materials	3
Tex-236-F (Correction Factors)	Asphalt Content from Asphalt Paving Mixtures by the Ignition Method (Determining Correction Factors)	4
Tex-236-F	Asphalt Content from Asphalt Paving Mixtures by the Ignition Method (Production Mixture)	1 (Note 2)
Tex-241-F **w/** Tex-207-F, Part I, **w/** Tex-227-F	**(Lab-Molded Density of Production Mixture – Superpave Gyratory)** Superpave Gyratory Compacting of Specimens of Bituminous Mixtures (production mixture) **with** Density of Compacted Bituminous Mixtures, Part I- Part I - Bulk Specific Gravity of Compacted Bituminous Mixtures, **with** Theoretical Maximum Specific Gravity of Bituminous Mixtures	1 (Note 2)
Tex-242-F	Hamburg Wheel-Tracking Test (production mix, molded samples)	3
Tex-244-F	Thermal Profile of Hot Mix Asphalt	1
Tex-246-F	Permeability of Water Flow of Hot Mix Asphalt	3
Tex-280-F	Flat and Elongated Particles	3
Tex-530-C	Effect of Water on Bituminous Paving Mixtures (production mix)	4

AGGREGATES		
Tex-400-A	Sampling Flexible Base, Stone, Gravel, Sand, and Mineral Aggregates	3
Tex-410-A	Abrasion of Coarse Aggregate Using the Los Angeles Machine	5
Tex-411-A	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate	12
Tex-461-A	Degradation of Coarse Aggregate by Micro-Deval Abrasion	5
CHEMICAL		
Tex-612-J	Acid Insoluble Residue for Fine Aggregate	4
GENERAL		
HMA Production Specialist [TxAPA – Level 1-A] ($/hr)		
HMA Roadway Specialist [TxAPA – Level 1-B] ($/hr)		
Technician Travel/Standby Time ($/hr)		
Per Diem ($/day – meals and lodging)		
Mileage Rate ($/mile from closest CL location)		

Note 1– Turn-Around Time includes test time and time for travel/sampling and reporting.
Note 2 – These tests require turn-around times meeting the governing specifications. Provide test results within the stated turn-around time. CL is allowed one additional day to provide the signed and sealed report.

Special Provision to Item 6
Control of Materials

Item 6, "Control of Materials" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 6.10., "Hazardous Materials," is voided and replaced by the following:

Comply with the requirements of Article 7.12., "Responsibility for Hazardous Materials."

Notify the Engineer immediately when a visual observation or odor indicates that materials on sites owned or controlled by the Department may contain hazardous materials. Except as noted herein, the Department is responsible for testing, removing, and disposing of hazardous materials not introduced by the Contractor. The Engineer may suspend work wholly or in part during the testing, removing, or disposing of hazardous materials, except in the case where hazardous materials are introduced by the Contractor.

Use materials that are free of hazardous materials. Notify the Engineer immediately if materials are suspected to contain hazardous materials. If materials delivered to the project by the Contractor are suspected to contain hazardous materials, have an approved commercial laboratory test the materials for the presence of hazardous materials as approved. Remove, remediate, and dispose of any of these materials found to contain hazardous materials. The work required to comply with this section will be at the Contractor's expense if materials are found to contain hazardous materials. Working day charges will not be suspended and extensions of working days will not be granted for activities related to handling hazardous material introduced by the Contractor. If suspected materials are not found to contain hazardous materials, the Department will reimburse the Contractor for hazardous materials testing and will adjust working day charges if the Contractor can show that this work impacted the critical path.

10.1. Painted Steel Requirements. Coatings on existing steel contain hazardous materials unless otherwise shown on the plans. Remove paint and dispose of steel coated with paint containing hazardous materials is in accordance with the following:

10.1.1. Removing Paint From Steel For contracts that are specifically for painting steel, Item 446, "Field Cleaning and Painting Steel" will be included as a pay item. Perform work in accordance with that item.

For projects where paint must be removed to allow for the dismantling of steel or to perform other work, the Department will provide for a separate contractor (third party) to remove paint containing hazardous materials prior to or during the Contract. Remove paint covering existing steel shown not to contain hazardous materials in accordance with Item 446, "Field Cleaning and Painting Steel."

10.1.2. Removal and Disposal of Painted Steel. For steel able to be dismantled by unbolting, paint removal will not be performed by the Department. The Department will remove paint, at locations shown on the plans or as agreed, for the Contractor's cutting and dismantling purposes. Utilize Department cleaned locations for dismantling when provided or provide own means of dismantling at other locations.

Painted steel to be retained by the Department will be shown on the plans. For painted steel that contains hazardous materials, dispose of the painted steel at a steel recycling or smelting facility unless otherwise shown on the plans. Maintain and make available to the Engineer invoices and other records obtained from the facility showing the received weight of the steel and the facility name. Dispose of steel that does not contain hazardous material coatings in accordance with federal, state and local regulations.

10.2. Asbestos Requirements. The plans will indicate locations or elements where asbestos containing materials (ACM) are known to be present. Where ACM is known to exist or where previously unknown ACM has been found, the Department will arrange for abatement by a separate contractor prior to or during the Contract. Notify the Engineer of proposed dates of demolition or removal of structural elements with ACM at least 60 days before beginning work to allow the Department sufficient time for abatement.

The Department of State Health Services (DSHS), Asbestos Programs Branch, is responsible for administering the requirements of the National Emissions Standards for Hazardous Air Pollutants, 40 CFR Part 61, Subpart M and the Texas Asbestos Health Protection Rules (TAHPR). Based on EPA guidance and regulatory background information, bridges are considered to be a regulated “facility” under NESHAP. Therefore, federal standards for demolition and renovation apply.

The Department is required to notify the DSHS at least 10 working days (by postmarked date) before initiating demolition or renovation of each structure or load bearing member shown on the plans. If the actual demolition or renovation date is changed or delayed, notify the Engineer in writing of the revised dates in sufficient time to allow for the Department’s notification to DSHS to be postmarked at least 10 days in advance of the actual work.

Failure to provide the above information may require the temporary suspension of work under Article 8.4., “Temporary Suspension of Work or Working Day Charges,” due to reasons under the control of the Contractor. The Department retains the right to determine the actual advance notice needed for the change in date to address post office business days and staff availability.

10.3. Lead Abatement. Provide traffic control as shown on the plans, and coordinate and cooperate with the third party and the Department for managing or removing hazardous materials. Work for the traffic control shown on the plans and coordination work will not be paid for directly but will be subsidiary to pertinent Items.

Special Provision to Item 6
Control of Materials

Item 6, "Control of Materials" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 1.1. "Buy America.," This section is voided and replaced by the following:

1.1. **Buy America**. Comply with the latest provisions of Build America, Buy America Act (BABA Act) of the Bipartisan Infrastructure Law and applicable CFR, which restrict funds being made available from Federal financial assistance programs unless all the iron products, steel products, manufactured products, and construction materials used in the project are produced in the United States. Use iron or steel products, manufactured products, or construction materials produced in the United States for all permanently installed materials and products except when defined in Section 1.1.5., "Buy America Exceptions."

A material is solely classified based on its status at the time it is brought to the work site as either an iron or steel product, construction material, manufactured product, or Section 70917(c) material. Refer to the Buy America Material Classification Sheet found in the general notes or txdot.gov for additional clarification on material classification.

1.1.1. **Iron or Steel**. Iron or steel products means articles, materials, or supplies that consist of iron or steel or a combination of both. For iron or steel products, manufacturing includes any process that modifies the chemical content, physical shape or size, or final finish of a product. The manufacturing process begins with initial melting and mixing and continues through fabrication (cutting, drilling, welding, bending, etc.) and coating (paint, galvanizing, epoxy, etc.).

For iron or steel products submit a notarized original FORM D-9-USA-1 (Department Form 1818) with the proper attachments for verification of compliance.

1.1.2. **Section 70917(c) Materials**. Section 70917(c) materials mean cement and cementitious material; aggregates such as stone, sand, or gravel; or aggregate binding agents or additives. Section 70917(c) materials do not require domestic sourcing or Buy America certification.

1.1.3. **Construction Materials**. Construction materials are classified as articles, materials, or supplies that consist of only one of the items listed in bullets below. Minor additions (as determined by plans or Engineer) to any of the items listed is still a construction material.

- non-ferrous metals,
- plastic and polymer-based products (including polyvinyl chloride, composite building materials, and polymers used in fiber optic cables),
- glass (including optic glass),
- fiber optic cable (including drop cable),
- optical fiber,
- lumber,
- engineered wood, or
- drywall.

For construction materials, submit a Construction Material Buy America Certification Form (Department Form 2806) for verification of compliance that all manufacturing processes, as required, occurred in the

United States. Each construction material has specific certification requirements stated below. Provide additional documentation as requested.

Details shown on the plans provide additional clarification on Buy America requirements.

For non-ferrous metals, certification requires all manufacturing processes, from initial smelting or melting through final shaping, coating, and assembly, occurred in the United States.

For plastic and polymer-based products (including polyvinyl chloride, composite building materials, and polymers used in fiber optic cables), certification requires all manufacturing processes, from initial combination of constituent plastic or polymer-based inputs, or, where applicable, constituent composite materials, until the item is in its final form, occurred in the United States.

For glass (including optic glass), certification requires all manufacturing processes, from initial batching and melting of raw materials through annealing, cooling, and cutting, occurred in the United States.

For fiber optic cable (including drop cable), certification requires all manufacturing processes, from the initial ribboning (if applicable), through buffering, fiber stranding and jacketing, occurred in the United States. All manufacturing processes also include the standards for glass and optical fiber, but not for non-ferrous metals, plastic and polymer-based products, or any others.

For optical fiber, certification requires all manufacturing processes, from the initial preform fabrication stage through the completion of the draw, occurred in the United States.

For lumber, certification requires all manufacturing processes, from initial debarking through treatment and planing, occurred in the United States.

For engineered wood, certification requires all manufacturing processes from the initial combination of constituent materials until the wood product is in its final form, occurred in the United States.

For drywall, certification requires all manufacturing processes, from initial blending of mined or synthetic gypsum plaster and additives through cutting and drying of sandwiched panels, occurred in the United States.

1.1.4. **Manufactured Products**. Materials classified as a manufactured product are currently waived from Buy America requirements by an FHWA general waiver and are not required to be domestically sourced. However, iron or steel products incorporated into manufactured products must meet iron and steel compliance requirements.

1.1.5. **Buy America Exceptions**. Use of iron, steel, construction materials, and manufactured products manufactured in the United States is required unless the material meets an exception below.

- A waiver exists exempting the material from Buy America compliance.
- The total value of the non-compliant products (other than iron or steel products) is no more than the lesser of $1,000,000 or 5% of Total Applicable Costs for the project. Total Applicable Cost means the actual cost of all materials requiring Buy America compliance including iron, steel, or other materials that are within the scope of existing waivers. Contractor must provide documentation showing under threshold in advance for Engineer's consideration.
- The total value of foreign iron and steel products, including delivery, does not exceed 0.1% of the total Contract cost or $2,500, whichever is greater. Contractor must provide documentation showing under threshold in advance for Engineer's consideration.
- Foreign steel may be allowed when the Contract contains an alternate item for a foreign source iron or steel product and the Contract is awarded based on the alternate item.

- The materials are temporarily installed or are supplies, tools and equipment not incorporated into the project. Temporarily installed means the materials and products must be removed at the end of the project or may be removed at the contractor's convenience with Engineers approval.

Special Provision to Item 7
Legal Relations and Responsibilities

Item 7, "Legal Relations and Responsibilities," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 7.7.2., "Texas Pollutant Discharge Elimination System (TPDES) Permits and Storm Water Pollution Prevention Plans (SWP3)," is voided and replaced by the following:

7.2. Texas Pollution Discharge Elimination System (TPDES) Permits and Storm Water Pollution Prevention Plans (SWP3).

7.2.1. Projects with less than one acre of soil disturbance including required associated project specific locations (PSL's) per TPDES GP TXR 150000.

No posting or filing will be required for soil disturbances within the right of way. Adhere to the requirements of the SWP3.

7.2.2. Projects with one acre but less than five acres of soil disturbance including required associated PSL's per TPDES GP TXR 150000.

The Department will be considered a primary operator for Operational Control Over Plans and Specifications as defined in TPDES GP TXR 150000 for construction activity in the right of way. The Department will post a small site notice along with other requirements as defined in TPDES GP TXR 150000 as the entity of having operational control over plans and specifications for work shown on the plans in the right of way.

The Contractor will be considered a Primary Operator for Day-to-Day Operational Control as defined in TPDES GP TXR 150000 for construction activity in the right of way. In addition to the Department's actions, the Contractor will post a small site notice along with other requirements as defined in TPDES GP TXR 150000 as the entity of having day-to-day operational control of the work shown on the plans in the right of way. This is in addition to the Contractor being responsible for TPDES GP TXR 150000 requirements for on- right of way and off- right of way PSL's. Adhere to all requirements of the SWP3 as shown on the plans. The Contractor will be responsible for Implement the SWP3 for the project site in accordance with the plans and specifications, TPDES General Permit TXR150000, and as directed.

7.2.3. Projects with 5 acres or more of soil disturbance including required associated PSL's per TPDES GP TXR 150000.

The Department will be considered a primary operator for Operational Control Over Plans and Specifications as defined in TPDES GP TXR 150000 for construction activities in the right of way. The Department will post a large site notice, file a notice of intent (NOI), notice of change (NOC), if applicable, and a notice of termination (NOT) along with other requirements per TPDES GP TXR 150000 as the entity having operational control over plans and specifications for work shown on the plans in the right of way.

The Contractor will be considered a primary operator for Day-to-Day Operational Control as defined in TPDES GP TXR 150000 for construction activities in the right of way. In addition to the Department's actions, the Contractor shall file a NOI, NOC, if applicable, and NOT and post a large site notice along with other requirements as the entity of having day-to-day operational control of the work shown on the plans in the right of way. This is in addition to the Contractor

being responsible for TPDES GP TXR 150000 requirements for on- right of way and off- right of way PSL's. Adhere to all requirements of the SWP3 as shown on the plans.

Special Provision to Item 7
Legal Relations and Responsibilities

Item 7, "Legal Relations and Responsibilities" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 19.1., Minimum Wage Requirements for Federally Funded Contracts. The second paragraph is voided and replaced by the following:

Submit electronic payroll records to the Engineer using the Department's payroll system.

Section 19.2., Minimum Wage Requirements for State Funded Contracts. The second paragraph is voided and replaced by the following:

Submit electronic payroll records to the Engineer using the Department's payroll system.

Special Provision to Item 7
Legal Relations and Responsibilities

Item 7, "Legal Relations and Responsibilities," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 7.2.4., "Public Safety and Convenience." The first paragraph is deleted and replaced by the following.

Ensure the safety and convenience of the public and property as provided in the Contract and as directed. Keep existing roadways open to traffic or construct and maintain detours and temporary structures for safe public travel. Manage construction to minimize disruption to traffic. Maintain the roadway in a good and passable condition, including proper drainage and provide for ingress and egress to adjacent property.

If the construction of the project requires the closing of a highway, as directed, coordinate the closure with the Engineer and work to ensure all lanes and ramps possible are available during peak traffic periods before, during, and after significant traffic generator events to avoid any adverse economic impact on the municipalities during:

- dates or events as shown on the plans, and
- other dates as directed.

Special Provision to Item 007
Legal Relations and Responsibilities

Item 7, "Legal Relations and Responsibilities," of the Standard Specifications is amended with respect to the clauses cited below.

Section 2.6., "Barricades, Signs, and Traffic Handling," the first paragraph is voided and replaced by the following:

2.6. **Barricades, Signs, and Traffic Handling.** Comply with the requirements of Item 502 "Barricades, Signs, and Traffic Handling," and as directed. Provide traffic control devices that conform to the details shown on the plans, the TMUTCD, and the Department's Compliant Work Zone Traffic Control Device List maintained by the Traffic Safety Division. When authorized or directed, provide additional signs or traffic control devices not required by the plans.

Section 2.6.1., "Contractor Responsible Person and Alternative," is voided and replaced by the following:

2.6.1. **Contractor Responsible Person and Alternative.** Designate in writing, a Contractor's Responsible Person (CRP) and an alternate to be the representative of the Contractor who is responsible for taking or directing corrective measures regarding the traffic control. The CRP or alternate must be accessible by phone 24 hr. per day and able to respond when notified. The CRP and alternate must comply with the requirements of Section 2.6.5., "Training."

Section 2.6.2, "Flaggers," the first paragraph is voided and replaced by the following:

2.6.2. **Flaggers.** Designate in writing, a flagger instructor who will serve as a flagging supervisor and is responsible for training and assuring that all flaggers are qualified to perform flagging duties. Certify to the Engineer that all flaggers will be trained and make available upon request a list of flaggers trained to perform flagging duties.

Section 2.6.5, "Training," is voided and replaced by the following:

2.6.5. **Training.** Train workers involved with the traffic control using Department-approved training as shown on the "Traffic Control Training" Material Producer List.

Coordinate enrollment, pay associated fees, and successfully complete Department-approved training or Contractor-developed training. Training is valid for the period prescribed by the provider. Except for law enforcement personnel training, refresher training is required every 4 yr. from the date of completion unless otherwise specified by the course provider. The Engineer may require training at a frequency instead of the period prescribed based on the Department's needs. Training and associated fees will not be measured or paid for directly but are considered subsidiary to pertinent Items.

Certify to the Engineer that workers involved in traffic control and other work zone personnel have been trained and make available upon request a copy of the certification of completion to the Engineer. Ensure the following is included in the certification of completion:

- name of provider and course title,
- name of participant,
- date of completion, and
- date of expiration.

Where Contractor-developed training or a Department-approved training course does not produce a certification, maintain a log of attendees. Make the log available upon request. Ensure the log is legible and includes the following:

- printed name and signature of participant,
- name and title of trainer, and
- date of training.

2.6.5.1. **Contractor-developed Training.** Develop and deliver Contractor-developed training meeting the minimum requirements established by the Department. The outline for this training must be submitted to the Engineer for approval at the preconstruction meeting. The CRP or designated alternate may deliver the training instead of the Department-approved training. The work performed and materials furnished to develop and deliver the training will not be measured or paid for directly but will be considered subsidiary to pertinent Items.

2.6.5.1.1. **Flagger Training Minimum Requirements.** A Contractor's certified flagging instructor is permitted to train other flaggers.

2.6.5.1.2. **Optional Contractor-developed Training for Other Work Zone Personnel.** For other work zone personnel, the Contractor may provide training meeting the curriculum shown below instead of Department-approved training.

Minimum curriculum for Contractor-provided training is as follows:

Contractor-developed training must provide information on the use of personnel protection equipment, occupational hazards and health risks, and other pertinent topics related to traffic management. The type and amount of training will depend on the job duties and responsibilities. Develop training applicable to the work being performed. Develop training to include the following topics.

- The Life You Save May Be Your Own (or other similar company safety motto).
- Purpose of the training.
  - It's the Law.
  - To make work zones safer for workers and motorist.
  - To understand what is needed for traffic control.
  - To save lives including your own.
- Personal and Co-Worker Safety.
  - **High Visibility Safety Apparel.** Discuss compliant requirements; inspect regularly for fading and reduced reflective properties; if night operations are required, discuss the additional and appropriate required apparel in addition to special night work risks; if moving operations are underway, discuss appropriate safety measures specific to the situation and traffic control plan.
  - **Blind Areas.** A blind area is the area around a vehicle or piece of construction equipment not visible to the operators, either by line of sight or indirectly by mirrors. Discuss the "Circle of Safety" around equipment and vehicles; use of spotters; maintain eye contact with equipment operators; and use of hand signals.
  - **Runovers and Backovers.** Remain alert at all times; keep a safe distance from traffic; avoid turning your back to traffic and if you must then use a spotter; and stay behind protective barriers, whenever possible. Note: It is not safe to sit on or lean against a concrete barrier, these barriers can deflect four plus feet when struck by a vehicle.
  - Look out for each other, warn co-workers.
  - Be courteous to motorists.
  - Do not run across active roadways.
  - Workers must obey traffic laws and drive courteously while operating vehicles in the work zones.
  - Workers must be made aware of company distracted driving policies.
- **Night Time Operations.** Focus should be placed on projects with a nighttime element.

- **Traffic Control Training.** Basics of Traffic Control.
  - Identify work zone traffic control supervisor and other appropriate persons to report issues to when they arise.
  - Emphasize that work zone traffic control devices must be in clean and in undamaged condition. If devices have been hit but not damaged, put back in their correct place and report to traffic control supervisor. If devices have been damaged, replace with new one and report to traffic control supervisor. If devices are dirty, faded or have missing or damaged reflective tape clean or replace and report to traffic control supervisor. Show examples of non-acceptable device conditions. Discuss various types of traffic control devices to be used and where spacing requirements can be found.
  - **Channelizing Devices and Barricades with Slanted Stripes.** Stripes are to slant in the direction you want traffic to stay or move to; demonstrate this with a device.
  - **Traffic Queuing.** Workers must be made aware of traffic queuing and the dangers created by it. Workers must be instructed to immediately notify the traffic control supervisor and other supervisory personnel if traffic is queuing beyond advance warning sign and devices or construction limits.
  - **Signs.** Signs must be straight and not leaning. Report problems to the traffic control supervisor or other as designated for immediate repair. Covered signs must be fully covered. If covers are damaged or out of place, report to traffic control supervisor or other as designated.

Special Provision to Item 7
Legal Relations and Responsibilities

Item 7, "Legal Relations and Responsibilities" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 7.20., "Security Incidents," is added**.**

20.1. **Reporting of Security Incidents.** Immediately notify the Department's Cyber Security Operations Center (CSOC) via the Report Cybersecurity Incident Page on www.txdot.gov, of any potential cybersecurity incident or breach involving Department data**.** A breach of system security is the unauthorized acquisition of computerized data that compromises the security, confidentiality, or integrity of sensitive personal information maintained by a person, including data that is encrypted if the person accessing the data has the key required to decrypt the data.

20.2. **Liability for costs incurred.** The Department reserves the right to hold the Contractor liable for all costs incurred by the Department to resolve a security incident introduced by the Contractor, their Subcontractors, or their Suppliers.

Special Provision to Item 8
Prosecution and Progress

Item 8, "Prosecution and Progress" of the Standard Specification is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 8.2., "Subcontracting," is supplemented by the following paragraph, which is added as paragraph six to this article:

The Contractor certifies by signing the Contract that the Contractor will not enter into any subcontract with a subcontractor that is not registered in the Department of Homeland Security's (DHS) E-Verify system. Require that all subcontractors working on the project register and require that all subcontractors remain active in the DHS E-Verify system until their work is complete on the project.

Special Provision to Item 8
Prosecution and Progress

Item 8, "Prosecution and Progress" of the Standard Specifications is amended with respect to the clause cited below. No other clauses or requirements of this Item are waived or changed.

Article 8.7.2., "Wrongful Default," is revised and replaced by the following:

If it is determined after the Contractor is declared in default, that the Contractor was not in default, the rights and obligations of all parties will be the same as if termination had been issued for the convenience of the public as provided in Article 8.8 "Termination of Contract."

Special Provision to Item 8
Prosecution and Progress

Item 8, "Prosecution and Progress," of the Standard Specifications, is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 8.6., "Failure to Complete Work on Time," is supplemented by the following:

8.6.1. Lane Closure Assessment Fees.

Monetary assessment, as shown on the plans, will be made against the Contractor for any lane closure or obstruction that overlaps into the peak hour traffic for each time increment defined on the plans or portion thereof, per lane, regardless of the length of lane closure or obstruction.

8.6.1.1. Definition of Terms. For this Contract, the following definitions apply:

8.6.1.1.1. Time increment. Any continuous defined increment of time period or portion thereof for a period beginning at that point when lanes are closed or obstructed by the Contractor's operations.

8.6.1.1.2. Assessment Fee. The amount shown on the proposal for each defined time increment, representing the average cost of interference and inconvenience to the road user for each lane closed or obstructed during peak hour traffic. The Engineer may allow a proportional fee assessment for closures that do not involve an entire defined time increment.

8.6.1.1.3. Closure or Obstruction. When the Contractor's operations result in a reduced lane width of the travel way or shoulder less than that specified on the plan documents.

8.6.1.1.4. Peak Hour Traffic Times. Schedule of days and times described in the General Notes, when lane closures or obstructions are not allowed.

8.6.1.2. Fee Calculation and Collection. The assessment fee will be deducted from the amount due to the Contractor on the monthly construction estimate, and thus retained by the Department. The Engineer will determine the time of overlap of lane closures or obstructions for calculating the assessment fee. The assessment fee is based on road user costs and is assessed not as a penalty, but for added expense incurred by the traveling public.

Special Provision to Item 8
Prosecution and Progress

Item 8, "Prosecution and Progress" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 3., "Computation of Contract Time for Completion." The second paragraph is voided and replaced by the following:

The development of the conceptual time determination is intended to establish the number of working days on the Contract. Upon request, the Engineer will provide the conceptual time determination schedule to the Contractor for informational purposes only. The schedule assumes generic resources, production rates, sequences of construction, and average weather conditions based on historic data. Schedule labor, equipment, procurement of materials, subcontractor work, and all other necessary means to prosecute the work within the number of working days specified by the Contract.

Special Provision to Item 8
Prosecution and Progress

Item 8, "Prosecution and Progress," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 8.1., "Prosecution of Work." The article is voided and replaced by the following.

Begin work within 60 calendar days after the authorization date to begin work. Prosecute the work continuously to completion within the working days specified. Unless otherwise shown on the plans, work may be prosecuted in concurrent phases if no changes are required to the traffic control plan or if a revised traffic control plan is approved. Notify the Engineer at least 24 hr. before beginning work or before beginning any new operation. Do not start new operations to the detriment of work already begun. Minimize interference to traffic.

For Contracts with callout work and work orders, begin work in the right of way within the specified time and continuously prosecute the work until completion.

Special Provision to Item 009
Measurement and Payment

Item 009 "Measurement and Payment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 9.5., "PROGRESS PAYMENTS" is supplemented with the following:

It is the Department's desire to pay a Contractor for work through the last working day of the month; however, the use of early cut-off dates for monthly estimates and MOH is a project management practice to manage workload at the Area Office level. Approval for using early cut-off dates is at the District's discretion. The earliest cut-off date for estimates is the 25th of the month.

Article 9.6., "PAYMENT FOR MATERIAL ON HAND (MOH)" first paragraph is amended as follows:

If payment for MOH is desired, request compensation for the invoice cost of acceptable nonperishable materials that have not been used in the work before the request, and that have been delivered to the work location or are in acceptable storage places. Nonperishable materials are those that do not have a shelf life or whose characteristics do not materially change when exposed to the elements. Include only materials that have been sampled, tested, approved, or certified, and are ready for incorporation into the work. Only materials which are completely constructed or fabricated on the Contractor's order for a specific Contract and are so marked and on which an approved test report has been issued are eligible. Payment for MOH may include the following types of items: concrete traffic barrier, precast concrete box culverts, concrete piling, reinforced concrete pipe, and illumination poles. Any repairs required after fabricated materials have been approved for storage will require approval of the Engineer before being made and will be made at the Contractor's expense. Include only those materials and products, when cumulated under an individual item or similar bid items, that have an invoice cost of at least $1,000 in the request for MOH payment (e.g. For MOH eligibility, various sizes of conductor are considered similar bid items and may be cumulated to meet the threshold; for small roadside signs, the sign supports, mounting bolts, and the sign face is considered one bid item or similar bid items for more than one pay item for sign supports.) Requests for MOH are to be submitted at least two days before but not later than the estimate cutoff date unless otherwise agreed. If there is a need to request MOH after the established cut-off date, the district can make accommodation as the need arises. This needed accommodation is to be the exception, though, and not the rule.

Special Provision to Item 9
Measurement and Payment

Item 9, "Measurement and Payment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 7.1.4.3., "Standby Equipment Costs," is voided and replaced by the following:

7.1.4.3. **Standby Equipment Costs.** Payment for standby equipment will be made in accordance with Section 9.7.1.4., "Equipment." The 15% markup will be paid when standby is associated with extra work but will not be paid when standby is associated with damages.

Section 7.1.4.3.1., "Contractor-Owned Equipment," is voided and replaced by the following:

7.1.4.3.1. **Contractor-Owned Equipment**. For Contractor-owned equipment:

- Standby will be paid at 50% of the monthly Rental Rate Blue Book rate after the regional and age adjustment factors have been applied. Operating costs will not be allowed. Calculate the standby rate as follows.

  Standby rate = (FHWA hourly rate - operating costs) × 50%

- If an hourly rate is needed, divide the monthly Rental Rate Blue Book rate by 176.
- No more than 8 hr. of standby will be paid during a 24-hr. day period, nor more than 40 hr. per week.
- Standby costs will not be allowed during periods when the equipment would have otherwise been idle.

Special Provision to Item 132
Embankment

Item 132, "Embankment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 132.2., "Materials", is supplemented with the following:

- **Type E.** Cement stabilized material consisting of Type CS select backfill meeting the requirements of Section 423.2.4.2.Table 2. Select Backfill Gradation Limits and hydraulic cement meeting the requirements of DMS-4600, "Hydraulic Cement," and the Department's Hydraulic Cement Quality Monitoring Program (HCQMP). Sources not on the HCQMP will require testing and approval before use.

Article 132.2., "Materials", the last paragraph is voided and not replaced.

Section 132.3.3, "Embankments Adjacent to Culverts and Bridges", is voided and replaced by the following:

132.3.3. Embankments Adjacent to Culverts and Bridges. Except as noted below, in Section 132.3.4, compact embankments adjacent to culverts, under bridge approach slabs, and adjacent to abutments where using Wide Flange Terminal Anchorage systems but not cement stabilized embankment, in accordance with Item 400, "Excavation and Backfill for Structures."

Section 132.3.4., "Compaction Methods", the first paragraph is supplemented by the following:

When cement stabilized backfill embankment, reinforced volume embankment, retaining wall foundation improvements, or embankment foundation improvements are shown on the plans, compact each layer to the required density, in accordance with Section 276.4.3, "Compaction."

Article 132.3., "Construction", is supplemented with the following:

Section 132.3.7 Cement Stabilized Backfill Embankment (CSBE). Provide Type E material for cement stabilized backfill embankment. Place CSBE for embankments, retaining wall foundation improvements, embankment foundation improvements and backfill material placed between the reinforced volume of retaining walls in accordance with the requirements of Section 423.2.4.4, "Cement Stabilized Backfill" at the locations shown on the plans or as directed.

Article 132.5., "Payment", the first paragraph is voided and replaced by the following:

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Embankment (Final)," "Embankment (Original)," or "Embankment (Vehicle)," of the compaction method and type specified. Where Cement Stabilized Backfill Embankment (CSBE) is shown on the plans, it will be paid for at the unit price bid for "Embankment (Final) (CSBE)", "Embankment (Final)(CSBE)(Retaining Wall Foundation Improvement)," "Embankment (Final)(CSBE)(Embankment Foundation Improvement)," or "Embankment (Final)(CSBE) (Reinforced Volume of Retaining Walls) of the compaction method and type shown on the plans. When the embankment adjacent to the cement stabilized reinforced volume is not cement stabilized, the cement stabilized reinforced volume will be paid as "Embankment (Final)" of the compaction method and type shown on the plans. This price is full compensation for all cement, cement treatment and stabilization, furnishing embankment, hauling, placing, compacting, curing, finishing, and reworking; disposal of waste material; and equipment, labor, tools, and incidentals.

Special Provision to Item 132
Embankment

Item 132, "Embankment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 132.3.4., "Compaction Methods." The last sentence is replaced by the following.

Compact embankments in accordance with Section 132.3.4.1., "Ordinary Compaction," or Section 132.3.4.2., "Density Control," as shown on the plans. The Contractor may use Section 132.3.4.3., "Density Control by Computer-Generated (CG) Curve," as an option for density control.

Article 132.3.4., "Compaction Methods," is supplemented by the following.

3.4.3. **Density Control by Computer-Generated (CG) Curve.** At the Contractor's discretion, CG curves may be used for density control.

Compact each layer to the required density using equipment complying with Item 210, "Rolling." Determine the maximum lift thickness based on the ability of the compacting operation and equipment to meet the required density. Do not exceed layer thickness of 12 in. loose or 10 in. compacted material, unless otherwise approved. Maintain a level layer with consistent thickness to ensure uniform compaction.

When using this method for each source and type of material, or when directed, sample and conduct testing according to the input parameters specified in Table 3 and provide CG field moisture-density curves based on each soil-compactor-lift thickness combination and CG Tex-114-E moisture-density curves based on each lift of soil. The CG field dry density (D_{fcg}) must be greater than or equal to the CG Tex-114-E maximum dry density (D_{acg}). The Engineer may obtain independent soil samples for supplemental Tex-114-E lab tests to check a supplemental maximum dry density (D_a) and optimum moisture content (W_{opt}) for reference when new CG curves are submitted. Provide access to the computer program used to generate the curve, when directed.

Table 3
Computer-Generated Lab and Field Compaction Curve Input Criteria

Input Variables	Test Method
Liquid Limit, %	Tex-104-E
Plasticity Index (PI), %	Tex-106-E
Soil gradation	Tex-110-E Tex-111-E
Soil classification	Tex-112-E
Compaction roller brand, type, and model	N/A
Loose lift thickness, in.	N/A
Soil specific gravity	Use 2.65 for soil type SC. Use 2.68 for soil type CL. Use 2.69 for soil type CH.

Provide a compaction control report showing all input and output parameters and CG compaction curves, including:

- CG Tex-114-E laboratory maximum dry density (D_{acg}),
- CG Tex-114-E laboratory optimum moisture content (W_{optcg}),
- CG field maximum dry density (D_{fcg}),

- CG field optimum moisture content (Wf_{optcg}),
- graph of CG laboratory and field compaction curves and the "Zero Air Voids Line," and
- minimum number of roller passes to achieve the required density and moisture content.

Meet the requirements for field maximum dry density (D_{fcg}) and field optimum moisture content (Wf_{optcg}) specified in Table 4, unless otherwise shown on the plans. Use only the specific roller and soil properties utilized in lift construction as input parameters to generate the CG field curve used to meet moisture-density requirements in construction.

Table 4
Computer-Generated Lab and Field Compaction Curve Input Criteria

Description	Density	Moisture Content
	Tex-115-E	
PI ≤ 15	≥ 98% D_{fcg}	≥ Wf_{optcg}
15 < PI ≤ 35	≥ 98% D_{fcg} and ≤ 102% D_{fcg}	≥ Wf_{optcg}
PI > 35	≥ 95% D_{acg} and ≤ 100% D_{acg}	≥ Wf_{optcg}

Each layer is subject to testing by the Engineer for density and moisture content. During compaction, the moisture content of the soil should be above CG optimum moisture content but should not exceed the value shown on the moisture-density curve, above optimum, required to achieve 98% dry density.

When the CG field maximum dry density (D_{fcg}) is not achieved, perform the following steps in order.

- Verify that construction controls including lift soil properties, minimum number and uniformity of compactor passes, lift thickness, and moisture content are correct.
- If needed, rework the lift with the corrected controls using the original CG curve.
- Generate a new CG field compaction curve based on actual in-place soil properties and rework the lift.
- Generate a non-CG Tex-114-E moisture-density reference standard and rework the material using this reference standard.

When required, remove small areas of the layer to allow for density tests. Replace the removed material and recompact at no additional expense to the Department. Proof-roll in accordance with Item 216, "Proof Rolling," when shown on the plans or as directed. Correct soft spots as directed.

Article 132.3.5., "Maintenance of Moisture and Reworking." The first sentence is replaced by the following.

Maintain the density and moisture content once all requirements in Table 2 or 4 are met.

Special Provision to Item 247
Flexible Base

Item 247, "Flexible Base," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 247.2.1., "Aggregate." This Section is voided and replaced by the following.

Furnish aggregate of the type and grade shown on the plans and meeting the requirements shown in Table 1. Each source must meet Table 1 requirements for liquid limit, plasticity index, and wet ball mill for the grade specified. Do not use additives, such as but not limited to cement, emulsion, foamed asphalt, or lime, to modify aggregates to meet the requirements of Table 1, unless otherwise shown on the plans.

Unless otherwise shown on the plans, the unconfined compressive strength is waived when the flexible base material meets the #200 sieve requirement.

Table 1
Material Requirements

Property	Test Method	Grade 1–2[3]	Grade 3	Grade 4	Grade 5[3]
Master gradation sieve size (cumulative % retained)	Tex-110-E	–	–	As shown on the plans	–
2-1/2"		0	0		0
1-3/4"		0–10	0–10		0–5
7/8"		10–35	–		10–35
3/8"		30–65	–		35–65
#4		45–75	45–75		45–75
#40		65–90	50–85		70–90
#200[1, 2]		85–95	–		–
Liquid limit, % Max	Tex-104-E	40	40		35
Plasticity index, Max	Tex-106-E	10	12		10
Plasticity index, Min		As shown on the plans	As shown on the plans		As shown on the plans
Wet ball mill, % Max	Tex-116-E	40	–		40
Wet ball mill, % Max increase passing the #40 sieve		20	–		20
Min compressive strength[2], psi	Tex-117-E	–	–		–
lateral pressure 0 psi		35	–		–
lateral pressure 3 psi		–	–		90
lateral pressure 15 psi		175	–		175

1. The #200 sieve test is only required to meet the waiver of the unconfined compressive strength. The #200 sieve test requirement is only applicable to stockpile samples from Section 247.2.4.
2. Compressive strength and #200 sieve test requirements are waived when the flexible base is mixed with or without existing material and treated with cement, emulsion, foamed asphalt, or lime, unless otherwise shown on the plans.
3. Grade 3 may be substituted for Grade 1–2 or Grade 5 when the flexible base is mixed with or without existing material and treated with cement, emulsion, foamed asphalt, or lime, as approved. The Grade 3 flexible base must meet the wet ball mill requirements of Grade 1–2 or Grade 5.

Section 247.2.1.2.4., "Type D." The third sentence is voided and replaced by the following.

Crushed concrete must meet the requirements in Section 247.2.1.3., "Recycled Material," and be managed in a way to provide for uniform quality.

Section 247.2.1.3., "Recycled Material." This Section is voided and replaced by the following.

Reclaimed asphalt pavement (RAP) and other recycled materials may be used as shown on the plans. Request approval to blend two or more sources of recycled materials. When RAP is allowed, do not exceed 20% RAP by weight, unless otherwise shown on the plans. The percentage limitations for other recycled materials are as shown on the plans.

Provide recycled materials, other than RAP, that have a maximum sulfate content of 3,000 ppm when tested in accordance with Tex-145-E. Certify accordance with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." In addition, recycled materials must be free of reinforcing steel and other objectionable material and have at most 1.5% deleterious material when tested in accordance with Tex-413-A. The liquid limit, plasticity index, wet ball mill, and compressive strength for all recycled materials are waived. When using RAP, crush RAP so that 100% passes the 2-in. sieve and does not exceed a maximum percent loss from decantation of 5.0% when tested in accordance with Tex-406-A. Test RAP without removing the asphalt. The final product must meet the requirements shown in Table 1 for the grade specified, except when the Department requires a specific amount of Department-furnished RAP be added to the blend, unless otherwise shown on the plans.

The Contractor is responsible for uniformly blending the recycled material with the flexible base material to build a stockpile to meet the percentages required. Any Contractor-furnished surplus of recycled materials must remain the property of the Contractor. Remove Contractor-owned recycled materials from the project, and dispose of them in conformance with federal, state, and local regulations before project acceptance.

Section 247.2.4., "Stockpile Approval." This Section is added.

Stockpile is approved when the Engineer's test results meet the material requirements shown in Table 1.

Section 247.2.4.1., "Sampling." This Section is added.

The Contractor and the Engineer will sample flexible base from completed stockpiles in accordance with Tex-100-A. Personnel conducting sampling must be certified by the Department-approved soils and base certification program.

Sampling stockpiles may be located at the production site or at the project location. The Contractor must witness the Engineer's sampling and sample the stockpile for their own testing, and label as deemed necessary.

Sample the stockpile for the Engineer as shown on the plans. When the Contractor samples the stockpile for the Engineer, the Engineer will witness the sampling of material designated for the Engineer and the Materials and Tests Division (MTD). The Engineer will label their sampling containers as "Engineer" and "MTD," or as deemed necessary.

The Engineer will take immediate possession of the sample containers for the Engineer and MTD. The Engineer will maintain custody of the samples until all testing and reporting are completed.

Section 247.2.4.2., "Referee Testing." This Section is added.

Referee testing is applicable for stockpile testing only. MTD is the referee laboratory. MTD may designate a laboratory from the Department's MPL for *Commercial Laboratories Approved for Flexible Base Referee Requests* as the referee laboratory as deemed necessary. The designated laboratory must not perform any testing under this Item for the Engineer or Contractor.

The Contractor may request referee testing when the Engineer's test results fail to meet any of the material requirements shown in Table 1 and when the Contractor's sample from Section 247.2.4.1., "Sampling," for the same failing Department test passes. The tests must be performed by a laboratory on the Department's MPL for *Commercial Laboratories Approved for Flexible Base Referee Requests*. Submit the request by email within 5 working days after receiving failing test results from the Engineer. Include completed test reports passing the applicable requirements shown in Table 1 in the email.

Record and submit completed test reports electronically on Department-provided templates in their original format meeting the applicable material requirements shown in Table 1. Use Department-provided templates to record and calculate all test data. The Engineer and the Contractor will provide any available test results to the other party when requested.

Section 247.4.3., "Compaction." The first paragraph is voided and replaced by the following.

Compact using density control unless otherwise shown on the plans. Multiple lifts are permitted as shown on the plans or approved. Bring each layer to the moisture content directed. When necessary, sprinkle the material in accordance with Item 204, "Sprinkling." Maintain moisture during compaction within ±2.0% of the optimum moisture content as determined in accordance with Tex-113-E.

Section 247.4.3.2., "Density Control." This Section is voided and replaced by the following.

Compact to at least 100% of the maximum dry density and within ±2.0% of the optimum moisture content as determined in accordance with Tex-113-E, unless otherwise shown on the plans. Provide the Engineer with the beginning and ending station numbers of the area completed for testing. The Engineer will determine roadway density and moisture content of completed sections in accordance with Tex-115-E, Part I. The Engineer will determine random locations for testing in accordance with Tex-115-E, Part IV. Do not achieve density by drying the material after compaction.

When the density is less than 100% of the maximum dry density, the Engineer may perform additional testing to determine the extent of the area to correct. The Engineer may accept the section if no more than one of the five most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

Section 247.4.3.3., "Miscellaneous and Small Areas." This Section is added.

Miscellaneous areas are those that typically involve handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Miscellaneous and small areas are not subject to random sampling procedure but may be tested as directed.

Section 247.4.6., "Ride Quality." This Section is voided and replaced by the following.

Measurement of ride quality only applies to the final travel lanes that receive a one- or two-course surface treatment for the final riding surface, unless otherwise shown on the plans. Measure the ride quality of the base course either before or after the application of the prime coat, as directed, and before placement of the surface treatment. Use a certified profiler operator on the Department's MPL. When requested, furnish the Engineer with documentation for the person certified to operate the profiler.

Provide all profile data to the Engineer in electronic data files within 3 days of measuring the ride quality using the format specified in Tex-1001-S. The Engineer will use Department software to evaluate longitudinal profiles to determine areas requiring corrective action. Correct 0.1-mi. sections with an average international roughness index (IRI) value greater than 100 in. per mile to an IRI value of 100 in. per mile or less, unless otherwise shown on the plans. Re-profile and correct sections that fail to maintain ride quality before the placement of the surface treatment, as directed. Unless ride deterioration is due to environmental impact, traffic, or other incidents outside the Contractor's control, perform this work at no additional expense to the Department, as approved.

Special Provision to Item 300
Asphalt, Oils, and Emulsions

Item 300, “Asphalt, Oils, and Emulsions” of the Standard Specifications is replaced by Special Specification 3096, “Asphalts, Oils, and Emulsions.” All Item 300 Special Provisions are no longer available, beginning with the April 2022 letting.

Special Provision to Item 302
Aggregates for Surface Treatments

Item 302, "Aggregates for Seal Coats," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Section 2.1., "Aggregate." Tables 2 and 3 are voided and replaced by the following.

Table 2
Aggregate Gradation Requirements (Cumulative % Retained[1])

Sieve	Grade								
	1	2	3S[2]	3		4S[2]	4	5S[2]	5
				Non-Lightweight	Lightweight				
1"	-	-	-	-	-	-	-	-	-
7/8"	0–2	0	-	-	-	-	-	-	-
3/4"	20–35	0–2	0	0	0	-	-	-	-
5/8"	85–100	20–40	0–5	0–5	0–2	0	0	-	-
1/2"	-	80–100	55–85	20–40	10–25	0–5	0–5	0	0
3/8"	95–100	95–100	95–100	80–100	60–80	60–85	20–40	0–5	0–5
1/4"	-	-	-	95–100	95–100	-	-	65–85	-
#4	-	-	-	-	-	95–100	95–100	95–100	50–80
#8	99–100	99–100	99–100	98–100	98–100	98–100	98–100	98–100	98–100

1. Round test results to the nearest whole number.
2. Single-size gradation.

Table 3
Aggregate Quality Requirements

Property	Test Method	Requirement[1]	
		Minimum	Maximum
SAC	AQMP	As shown on the plans	
Deleterious Material[2], %	Tex-217-F, Part I	-	2.0
Decantation, %	Tex-406-A	-	1.5
Flakiness Index, %	Tex-224-F	-	17
Gradation	Tex-200-F, Part I	Table 2 Requirements	
Los Angeles Abrasion, %	Tex-410-A	-	35
Magnesium Sulfate Soundness, 5 Cycle, %	Tex-411-A	-	25
Micro-Deval Abrasion, %	Tex-461-A	Note 3	
Coarse Aggregate Angularity[4], 2 Crushed Faces, %	Tex-460-A, Part I	85	-
Additional Requirements for Lightweight Aggregate			
Dry Loose Unit Wt., lb./cu. ft.	Tex-404-A	35	60
Pressure Slaking, %	Tex-431-A	-	6.0
Freeze-Thaw Loss, %	Tex-432-A	-	10.0
Water Absorption, 24hr., %	Tex-433-A	-	12.0

1. Material requirements are listed below, unless otherwise shown on the plans.
2. Not required for lightweight aggregate.
3. Used to estimate the magnesium sulfate soundness loss in accordance with Section 2.1.1.
4. Only required for crushed gravel.

Section 2.1.1., "Micro-Deval Abrasion," is added.

The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source per project that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula.

$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
$MD_{act.}$ = actual Micro-Deval percent loss
RSMD = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved by the Engineer. The Engineer may require additional testing before granting approval.

Section 2.2., "Precoating." The third paragraph is voided and replaced by the following.

The Engineer retains the right to remove precoat material from aggregate samples in accordance with Tex-210-F, or as recommended by the Construction Division, and test the aggregate to verify compliance with Table 2 and Table 3 requirements. Gradation testing may be performed with precoat intact.

Section 2.3., "Sampling," is added.

Personnel who conduct sampling and witnessing of sampling must be certified by the Department-approved certification program. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning construction and when personnel changes are made. At any time during the project, the Engineer may perform production tests as deemed necessary in accordance with Item 5, "Control of the Work."

The Engineer will sample aggregate from stockpiles located at the production site, intermediate distribution site, or project location in accordance with Tex-221-F, Section 3.2.3. The Engineer will split each sample into 2 equal portions in accordance with Tex-200-F, Section 3.3, and label these portions "Engineer" and "Contractor" or "Supplier." Witness the sampling and splitting, and take immediate possession of the samples labeled "Contractor" or "Supplier".

Section 2.4., "Reporting and Responsibilities," is added.

The Engineer will provide test results to the Contractor and Supplier within 10 working days from the date the stockpile was sampled for sources listed on the Department's Bituminous Rated Source Quality Catalog (BRSQC), unless otherwise directed. The Engineer will provide test results for the LA Abrasion (Tex-410-A) and Magnesium Sulfate Soundness (Tex-411-A) tests within 30 calendar days for sources not listed on the BRSQC, or for sources not meeting the requirements of Section 2.1.1., "Micro-Deval Abrasion." The Engineer will report to the other party within 24 hours when any test result does not meet the requirements listed in Table 2 or Table 3.

Special Provision to Item 316
Seal Coat

Item 316, "Seal Coat" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 4.8, "Asphalt Placement" is supplemented by the following:

4.8.5. Collect all samples in accordance with Tex-500-C, "Sampling Bituminous Materials, Pre-Molded Joint Fillers, and Joint Sealers" from the distributor and with witness by the Engineer.

At least once per project, collect split samples of each binder grade and source used. The Engineer will submit one split sample to MTD for testing and retain the other split sample.

In addition, collect one sample of each binder grade and source used on the project for each production day. The Engineer will retain these samples.

The Engineer will keep all retained samples for one yr., for hot-applied binders and cutback asphalts; or for two mo., for emulsified asphalts. The Engineer may submit retained samples to MTD for testing as necessary or as requested by MTD.

Special Provision to Item 334
Hot-Mix Cold-Laid Asphalt Concrete Pavement

Item 334, "Hot-Mix Cold-Laid Asphalt Concrete Pavement," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed hereby.

Section 334.4.1.2., "Job-Mix Formula Approval." Table 5 is voided and replaced by the following:

Table 5
Laboratory Mixture Design Properties

Property	Test Method	Requirement
Target laboratory-molded density, %[1]	Tex-207-F	94.0 ± 1.5
Hveem stability, Min	Tex-208-F	35
Cantabro loss, %, Max	Tex-245-F	10
Hydrocarbon-volatile content, %, Max	Tex-213-F	0.6
Moisture content, %, Max[2]	Tex-212-F	1.0
Boil test, %, Max[3]	Tex-530-C	10

1. Unless otherwise shown on the plans.
2. Unless otherwise approved.
3. Limit may be increased or eliminated when approved.

Special Provision to Item 340
Dense-Graded Hot-Mix (Small Quantity)

Item 340, “Dense-Graded Hot-Mix (Small Quantity)” of the Standard Specifications is replaced by Special Specification 3076, “Dense-Graded Hot-Mix Asphalt,” Section 4.9.4., “Exempt Production.” All Item 340 Special Provisions and bid codes are no longer available, beginning with the February 2022 letting.

Special Provision to Item 341
Dense-Graded Hot-Mix Asphalt

Item 341, “Dense-Graded Hot-Mix Asphalt” of the Standard Specifications is replaced by Special Specification 3076, “Dense-Graded Hot-Mix Asphalt.” All Item 341 Special Provisions and bid codes are no longer available, beginning with the February 2020 letting.

Special Provision to Item 342
Permeable Friction Course (PFC)

Item 342, “Permeable Friction Course (PFC)” of the Standard Specifications is replaced by Special Specification 3079, “Permeable Friction Course.” All Item 342 Special Provisions and bid codes are no longer available, beginning with the April 2022 letting.

Special Provision to Item 347
Thin Overlay Mixture (TOM)

Item 347, “Thin Overlay Mixture (TOM)” of the Standard Specifications is replaced by Special Specification 3081, “Thin Overlay Mixture (TOM). All Item 347 Special Provisions and bid codes are no longer available, beginning with the April 2022 letting.

Special Provision to Item 348
Thin Bonded Friction Courses

Item 348, “Thin Bonded Friction Courses” of the Standard Specifications is replaced by Special Specification 3082, “Thin Bonded Friction Courses.” All Item 348 Special Provisions and bid codes are no longer available, beginning with the April 2022 letting.

Special Provision to Item 360
Concrete Pavement

Item 360, "Concrete Pavement" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 360.2.1., "Materials," the third paragraph is voided and replaced by the following:

For continuously reinforced concrete pavements, use a coarse aggregate with a rated coefficient of thermal expansion of not more than 5.5×10^{-6} in./in./°F as listed in the Department's *Concrete Rated Source Quality Catalog*.

Section 360.4.8.3., "Surface Texture," the second paragraph is voided and replaced by the following:

A metal-tine texture finish is required unless otherwise shown on the plans. Provide transverse or longitudinal tining unless otherwise shown on the plans. Immediately following the carpet drag, apply a single coat of evaporation retardant, if needed, at the rate recommended by the manufacturer. Provide the metal-tine finish immediately after the concrete surface has set enough for consistent tining. Operate the metal-tine device to obtain grooves approximately 3/16 in. deep, with a minimum depth of 1/8 in., and approximately 1/12 in. wide. Do not overlap a previously tined area. Use manual methods to achieve similar results on ramps, small or irregular areas, and narrow width sections of pavements. Repair damage to the edge of the slab and joints immediately after texturing. Do not tine pavement that will be overlaid or that is scheduled for blanket diamond grinding or shot blasting.

Special Provision to Item 420
Concrete Substructure

Item 420, “Concrete Substructures” of the Standard Specifications is amended with respect to the clause cited below. No other clauses or requirements of this Item are waived or changed.

Article 420.6., “Payment.” The first paragraph is replaced by the following:

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for the class of concrete and element identified and by the special designation when appropriate. This price is full compensation for furnishing, hauling, and mixing concrete materials; furnishing, bending, fabricating, splicing, welding and placing the required reinforcement; clips, blocks, metal spacers, ties, wire, or other materials used for fastening reinforcement in place; placing, finishing, and curing concrete; mass placement controls; applying ordinary surface finish; furnishing and placing drains, metal flashing strips, and expansion-joint material; excavation, subgrade preparation; and forms and falsework, equipment, labor, tools, and incidentals.

Special Provision to Item 421
Hydraulic Cement Concrete

Item 421, "Hydraulic Cement Concrete" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 421.2., "Materials," the second sentence of the first paragraph is voided and replaced by the following.

Provide aggregates from sources listed in the Department's Concrete Rated Source Quality Catalog (CRSQC).

Article 421.2.2., Supplementary Cementing Materials (SCM), is voided and replaced with the following.

Supplementary Cementitious Materials (SCM).

- **Coal Ash**. Furnish sources of fly ash, , Modified fly ash (MFA), harvested coal ash, and Ground Bottom Ash (GBA) conforming to DMS-4610, "Coal Ash."
- **Slag Cement**. Furnish Slag Cement in accordance with DMS-4620, "Slag Cement."
- **Silica Fume**. Furnish silica fume in accordance with DMS-4630, "Silica Fume."
- **Natural Pozzolans**. Furnish Natural Pozzolans in accordance with DMS-4635, "Natural Pozzolans."

Article 421.3.1.3., "Agitators and Truck and Stationary Mixers," the first paragraph is voided and replaced by the following.

Provide stationary and truck mixers capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and capable of discharging the concrete so that the requirements of Tex-472-A are met.

Article 421.3.1.3., "Agitators and Truck and Stationary Mixers," is supplemented with the following.

Truck mixers with automated water and chemical admixture measurement and slump and slump flow monitoring equipment meeting the requirement of ASTM C94 will be allowed. Provide data every 6 mo. substantiating the accuracy of slump, slump flow, temperature, water, and chemical admixture measurements. The slump measured by the automated system must be within 1 in. of the slump measured in accordance with Tex-415-A. The concrete temperature measured by the automated system must be within 1°F of concrete temperature measured in accordance with Tex-422-A. The Engineer will not use the automated measurements for acceptance.

Article 421.4.2., "Mix Design Proportioning," Table 8 is voided and replaced by the following.

Table 8
Concrete Classes

Class of Concrete	Design Strength,[1] Min f'_c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]
A	3,000	0.60	1–4, 8	I, II, I/II, IL, IP, IS, IT, V	1, 2, 4, & 7	When the cementitious material content does not exceed 520 lb./cu. yd., any coal ash or natural pozzolan listed in the MPL may be used at a cement replacement of 20% to 50%.	Curb, gutter, curb & gutter, conc. retards, sidewalks, driveways, back-up walls, anchors, non-reinforced drilled shafts
B	2,000	0.60	2–7				Riprap, traffic signal controller foundations, small roadside signs, and anchors
C[6]	3,600	0.45	1–6	I, II, I/II, IP, IL, IS, IT, V	1–8		Drilled shafts, bridge substructure, traffic rail, culverts except top slab of direct traffic culverts, headwalls, wing walls, inlets, manholes, traffic barrier
E	3,000	0.50	2–5	I, II, I/II, IL, IP, IS, IT, V	1–8	When the cementitious material content does not exceed 520 lb./cu. yd., any coal ash or natural pozzolan listed in the MPL may be used at a cement replacement of 20% to 50%.	Seal concrete
F[6]	Note[7]	0.45	2–5	I, II, I/II, IP, IL, IS, IT, V			Railroad structures; occasionally for bridge piers, columns, bents, post-tension members
H[6]	Note[7]	0.45	3–6	I, II, I/II, III, IP, IL, IS, IT, V	1–4, 8	Mix design options 1-8 allowed for cast-in-place concrete and the following precast elements unless otherwise stated in the plans: ■ Bridge Deck Panels, ■ Retaining Wall Systems, ■ Coping, ■ Sound Walls, ■ Wall Columns, ■ Traffic Rail, ■ Traffic Barrier, ■ Long/Arch Span Culverts, and ■ precast concrete products included in Item 462, "Concrete Box Culverts and Drains, Item 464, "Reinforced Concrete Pipe," and Item 465, "Junction Boxes, Manholes, and Inlets." Do not use Type III cement in mass placement concrete. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete. Options 6, & 7 allowed for cast-in-place Class H concrete.	Precast concrete, post-tension members
S[6]	4,000	0.45	2–5	I, II, I/II, IP, IL, IS, IT, V	1–8		Bridge slabs, top slabs of direct traffic culverts, approach slabs

Class of Concrete	Design Strength,[1] Min f'_c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]
P	See Item 360, "Concrete Pavement."	0.50	2–3	I, II, I/II, IL, IP, IS, IT, V	1–8	When the cementitious material content does not exceed 520 lb./cu. yd., any coal ash or natural pozzolan listed in the MPL's may be used at a cement replacement of 20% to 50%.	Concrete pavement
CO[6]	4,600	0.40	6	I, II, I/II, IP, IL, IS, IT, V	1–8		Bridge deck concrete overlay
LMC[6]	4,000	0.40	6–8				Latex-modified concrete overlay
SS[6]	3,600	0.45	4–6		1-8	Use a Min cementitious material content of 658 lb./cu. yd. of concrete. Limit the alkali loading to 4.0 lbs./cu. yd. or less when using Option 7.	Slurry displacement shafts, underwater drilled shafts
K[6]	Note[7]	0.40	Note[7]	I, II, I/II, III IP, IL, IS, IT, V	1-8		Note[7]
HES	Note[7]	0.45	Note[7]	I, IL, II, I/II, III		Mix design options do not apply. 700 lb. of cementitious material per cubic yard limit does not apply.	Concrete pavement, concrete pavement repair
"X" (HPC) [6,8,9]	Note[10]	0.45	Note[10]	I, II, I/II, III IP, IL, IS, IT, V	1–4, & 8	Max coal ash replacement for Option 3 may be increased to 50%. Up to 20% of a blended cement may be replaced with listed SCMs for Option 4. Do not use Option 8 for precast concrete.	
"X" (SRC) [6,8,9]	Note[10]	0.45	Note[10]	I/II, II, IP, IL (MS or HS), IS, IT (MS or HS), V	1–4, & 7	When using coal ash, only use coal ashes allowed for SRC as listed in the Coal Ash MPL. Type III-MS may be used where allowed. Type I, Type IL, and Type III cements may be used when natural pozzolans are used or when coal ashes allowed for SRC as listed in the Coal Ash MPL are used, and with a Max w/cm of 0.40. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete. Use Option 7 for precast concrete where allowed.	

1. Design strength must be attained within 56 days.
2. Do not use Grade 1 coarse aggregate except in massive foundations with 4 in. Min clear spacing between reinforcing steel bars, unless otherwise permitted. Do not use Grade 1 aggregate in drilled shafts.
3. Use Grade 8 aggregate in extruded curbs unless otherwise approved.
4. Other grades of coarse aggregate maybe used in non-structural concrete classes when allowed by the Engineer.
5. For information only.
6. Structural concrete classes.
7. As shown on the plans or specified.
8. "X" denotes class of concrete shown on the plans or specified.
9. (HPC): High Performance Concrete, (SRC): Sulfate Resistant Concrete.
10. Same as class of concrete shown on the plans.

Article 421.4.2.2., "Aggregates," is supplemented by the following.

Use the following equation to determine if the aggregate combination meets the sand equivalency requirement when blending fine aggregate or using an intermediate aggregate:

$$\frac{(SE_1 \times P_1)+(SE_2 \times P_2)+(SE_{ia} \times P_{ia})}{100} \geq 80\%$$

where:
SE_1 = sand equivalency (%) of fine aggregate 1
SE_2 = sand equivalency (%) of fine aggregate 2
SE_{ia} = sand equivalency (%) of intermediate aggregate passing the 3/8 in. sieve
P_1 = percent by weight of fine aggregate 1 of the fine aggregate blend
P_2 = percent by weight of fine aggregate 2 of the fine aggregate blend
P_{ia} = percent by weight of intermediate aggregate passing the 3/8 in. sieve

Article 421.4.2.3., Chemical Admixtures," the second paragraph is voided and replaced with the following.

Use a 30% calcium nitrite solution when a corrosion-inhibiting admixture is required. Dose the admixture at the rate of gallons of admixture per cubic yard of concrete shown on the plans. Use set retarding admixtures, as needed, to control setting time to ensure concrete containing corrosion inhibiting admixtures remain workable for the entire duration of the concrete placement. Perform setting time testing and slump loss testing during trial batch testing.

Article 421.4.2.5., "Slump," the second paragraph is voided and not replaced. Table 9 is voided and replaced with below:

Table 9
Placement Slump Requirements

General Usage	Placement Slump Range,[1,2] in.
Walls (over 9 in. thick), caps, columns, piers	3 – 7
Bridge slabs, top slabs of direct traffic culverts, approach slabs, concrete overlays, latex-modified concrete for bridge deck overlays	3 – 6
Inlets, manholes, walls (less than 9 in. thick), bridge railing, culverts, concrete traffic barrier, concrete pavement (formed)	4 – 6
Precast concrete	4 – 9
Underwater concrete placements	6 – 8-1/2
Drilled shafts, slurry displaced and underwater drilled shafts	See Item 416, "Drilled Shaft Foundations."
Curb, gutter, curb and gutter, concrete retards, sidewalk, driveways, seal concrete, anchors, riprap, small roadside sign foundations, concrete pavement repair, concrete repair	As approved

1. Max slump values may be increase above these values shown using chemical admixtures, provided the admixture treated concrete has the same or lower water-to-cementitious ratio and does not exhibit segregation or excessive bleeding. Request approval to increase slump limits in advance for proper evaluation by the Engineer.
2. For fiber reinforced concrete, perform slump before addition of fibers.

Article 421.4.2.6., "Mix Design Options," is voided and replaced with the following.

Option 1. Replace cement with at least the minimum dosage listed in the MPL for the coal ash or natural pozzolan used in the mixture. Do not replace more than 50% of the cement. Conduct Option 8 testing as listed on the MPL.

Option 2. Replace 35% to 50% of the cement with slag cement.

Option 3. Replace 35% to 50% of the cement with a combination of coal ash, slag cement, natural pozzolan, or at least 3% silica fume; however, no more than 10% may be silica fume.

Option 4. Use Type IP, Type IS, or Type IT cement as allowed in Table 8 for each class of concrete. When replacing blended cements with additional SCM's, the replacement limits in Option 3 will apply to the final cementitious mixture. When using coal

ash or natural pozzolans not having a minimum dosage listed in the MPL in the final cementitious mixture, perform Option 8 testing.

Option 5. Option 5 is left intentionally blank.

Option 6. Use a lithium nitrate admixture at a minimum dosage determined by testing conducted in accordance with Tex-471-A. Before use of the mix, provide an annual certified test report signed and sealed by a licensed professional engineer, from a laboratory listed on the MPL, certified by the Materials and Tests Division as being capable of testing according to Tex-471-A.

Option 7. Ensure the total alkali contribution from the cement in the concrete does not exceed 3.5 lb. per cubic yard of concrete when using hydraulic cement not containing SCMs calculated as follows:

$$\text{lb. alkali per cu. yd.} = \frac{(\text{lb. cement per cu. yd.}) \times (\%\ Na_2O \text{ equivalent in cement})}{100}$$

In the above calculation, use the maximum cement alkali content reported on the cement mill certificate.

Option 8. Use Table 10 when deviating from Options 1–3 or when required by the Coal Ash MPL. Perform required testing annually and submit results to the Engineer. Laboratories performing ASTM C1260, ASTM C1567, and ASTM C1293 testing must be listed on the MPL. Before use of the mix, provide a certified test report signed and sealed by a licensed professional engineer demonstrating the proposed mixture in accordance with the requirements of Table 10.

Provide a certified test report signed and sealed by a licensed professional engineer, when HPC is required, and less than 20% of the cement is replaced with SCMs, demonstrating ASTM C1876 test results indicate the uniaxial resistivity of the concrete is greater than 15.6 kΩ-cm tested immediately after either of the following curing schedules:

- Moisture cure specimens 56 days at 73°F.
- Moisture cure specimens 7 days at 73°F followed by 21 days at 100°F.

Table 10
Option 8 Testing and Mix Design Requirements

Scenario	ASTM C1260 Result		Testing Requirements for Mix Design Materials or Prescriptive Mix Design Options
	Mix Design Fine Aggregate	Mix Design Coarse Aggregate	
A	> 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of each aggregate[1] to 0.10% when tested individually in accordance with ASTM C1567.
B	≤ 0.10%	≤ 0.10%	Use the Min replacement listed in the Coal Ash MPL, or when Option 8 is listed on the MPL, use a Min of 40% coal ash with a Max CaO[2] content of 25%, or use any ternary combination which replaces 35% to 50% of cement.
	≤ 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Use a minimum of 20% of any coal ash; or Use any ternary combination which replaces 20% to 50% of cement.
C	≤ 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of coarse and intermediate[1] aggregate to ≤0.10% when tested individually in accordance with ASTM C1567.
D	> 0.10%	≤ 0.10%	Use the Min replacement listed in the Coal Ash MPL, or when Option 8 is listed on the MPL, use a Min of 40% coal ash with a Max CaO[2] content of 25%, or use any ternary combination which replaces 35% to 50% of cement.
	> 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Determine the dosage of SCMs needed to limit the 14-day expansion of each fine aggregate to ≤0.10% when individually tested in accordance with ASTM C1567.

1. Intermediate size aggregates will fall under the requirements of mix design coarse aggregate.
2. Average the CaO content from the previous ten values as listed on the test certificate.

Article 421.4.2.7., "Optimized Aggregate Gradation (OAG) Concrete," the first sentence of the first paragraph is voided and replaced by the following.

The gradations requirements in Table 4 and Table 6 do not apply when OAG concrete is specified or used by the Contractor unless otherwise shown on the plans.

The fineness modulus for fine aggregate listed in Table 5, does not apply when OAG concrete is used,

Article 421.4.6.2., Delivering Concrete," the third paragraph is supplemented by the following.

When truck mixers are equipped with automated water or chemical admixture measurement and slump or slump flow monitoring equipment, the addition of water or chemical admixtures during transit is allowed. Reports generated by this equipment must be submitted to the Engineer daily.

Article 421.4.6.2., "Delivering Concrete," the fifth paragraph is voided and replaced with the following. Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14. Concrete delivered after these times, and concrete that has not begun to discharge within these times will be rejected.

Article 421.4.8.3., "Testing of Fresh Concrete," is voided and replaced with the following.

Testing Concrete. The Engineer, unless specified in other Items or shown on the plans, will test the fresh and hardened concrete in accordance with the following methods:

- Slump. Tex-415-A;
- Air Content. Tex-414-A or Tex-416-A;
- Temperature. Tex-422-A;
- Making and Curing Strength Specimens. Tex-447-A;
- Compressive Strength. Tex-418-A;
- Flexural Strength. Tex-448-A; and
- Maturity. Tex-426-A.

Flexural strength and maturity specimens will not be made unless specified in other items or shown on the plans.

Concrete with slump less than minimum required after all addition of water withheld will be rejected, unless otherwise allowed by the Engineer. Concrete with slump exceeding maximum allowed may be used at the Contractor's option. If used, Engineer will make, test, and evaluate strength specimens as specified in Article 421.5., "Acceptance of Concrete." Acceptance of concrete not meeting air content or temperature requirements will be determined by Engineer. Fresh concrete exhibiting segregation and excessive bleeding will be rejected.

Article 421.4.8.3.1., "Job-Control Testing," is voided and not replaced.

Special Provision to Item 423
Retaining Walls

Item 423, "Retaining Walls" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 423.2.1., "General" is supplemented with the following:

Construct permanent retaining walls approved for use in accordance with DMS 4800, "Proprietary Earth Retaining Wall System," and on the Approved System list for Concrete Block Retaining Walls Systems and Mechanically Stabilized Earth Panel Type Systems.

Article 423.2.4.2., "Select." The following sentence will be added to the fifth paragraph:

When Type CS select fill is used for cement stabilized backfill, the Plasticity Index (PI) as determined by Test Method Tex-106-E should not exceed six.

Special Provision to Item 426
Post-Tensioning

Item 426, "Post-Tensioning" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 2.1., "Prestressing Steel." The first bullet is voided and replaced with the following.

- Seven-wire steel strand meeting DMS-4500, "Steel Strand, Uncoated Seven-Wire Low Relaxation for Prestressed Concrete," or

Section 2.2., "Post-Tensioning System." The second bulleted item is voided and replaced with the following:

- Provide pre-packaged grouts in accordance with DMS-4670, "Grouts for Post-Tensioning." Do not use grouts that exceed the manufacturers' recommended shelf life or 6 mo. after date of manufacture, whichever is less.

Section 4.2., "Required Submittals." The section is voided and replaced with the following.

4.2. **Required Submittals.** Submit information required in this Section for post-tensioned elements, in addition to forming and falsework plans required by Item 420, "Concrete Substructures," and Item 424, "Precast Concrete Structural Members (Fabrication)." Include all necessary construction information in these submittals for cast-in-place and precast construction including, but not limited to the information required in this Section.

4.2.1. **Design Calculations**. Provide design procedures, coefficients, allowable stresses, tendon spacing, and clearances in accordance with the AASHTO LRFD *Bridge Design Specifications* and PTI/ASBI M50 unless otherwise shown on the plans. Submit enough calculations to support the proposed system and method of post-tensioning including friction loss diagrams. When the required jacking force for a particular type of tendon, duct, and configuration is furnished on the plans, design calculations are not required except to adjust for conditions different from those shown on the plans.

4.2.2. **Post-Tensioning Details**. Provide drawings with details that meet the requirements of PTI/ASBI M50 and this Specification.

4.2.3. **Grouting Plan**. Submit for approval written grouting procedures at least four weeks before the start of the element's construction. Include items required by PTI M55.

Include the names of people responsible for PT installation and grouting operations, with the foreman of each grouting crew certified as a PTI Level 2 Bonded PT Field Specialist and ASBI Certified Grouting Technician.

4.2.4. **Stressing Safety Plan**. Provide a plan to protect the public, workers, and Department personnel on and around the vicinity where post-tensioning operations are occurring.

Submit for approval, a detailed safety plan which identifies potential risk associated with post-tensioning operations, including but not limited to:

- tendon alignment,
- temporary shoring,
- ram operations, and
- stand anchorage.

Section 4.3., "Design Calculations." The section is voided and replaced with the following.

4.3. **Packaging, Storing, and Handling of Post-Tensioning Components**. Package, store, and handle post-tensioning steel, grout, duct, and other accessories in accordance with PTI/ASBI M50 and PTI M55 unless otherwise indicated. Acceptance and rejection criteria for strand will follow PTI/ASBI M50 and PTI M55.

The following exceptions apply:

- grout storage onsite will be limited to 30 days unless approval by the Engineer is given in advance of material delivery,
- install grout caps and ensure vents are closed at all times so that water and other contaminants cannot enter the duct before strand installation, and
- do not flush ducts at any time.

Section 4.4., "Packaging, Storing, and Handling of Post-Tensioning Components." The section is voided and replaced with the following.

4.4. **Duct and Prestressing Steel Installation for Post-Tensioning**. Follow PTI/ASBI M50 for duct and prestressing steel installation procedures and requirements unless otherwise specified. Verify that concrete strength requirements on the plans are met for stressing and staged loading of post-tensioned structural elements.

Stress the tendons within seven days of installing the strand in the ducts unless otherwise approved in advance. Follow the tensioning procedure noted in the approved post-tensioning details.

Section 4.5., "Duct and Prestressing Steel Installation for Post-Tensioning." The section is voided and replaced with the following.

4.5. **Grouting**. Grout in accordance with PTI M55.

Grout within 14 days of tendon stressing unless otherwise specified or approved. Obtain approval to extend the grouting time before stressing tendons.

Do not allow the grout temperature to exceed 85°F during mixing and pumping. Do not grout when the ambient temperature is below 35°F. Field-test the grout in accordance with Table 1 during grout installation. Perform field-testing by trained personnel at the Contractor's expense while witnessed by the Engineer. Pump at the lowest pressure possible that will maintain a continuous flow of grout.

Table1
Requirements for Field-Testing of Grout

Test	Frequency	Requirement
Schupak Pressure Bleed Test (ASTM C1741)	1 per day	Per DMS-4670
Fluidity test (Tex-437-A, Method 2)	2 every 2 hr. 2 min. per day	per DMS-4670
Compressive Strength test (3" × 6" cylinders)	1 per day	per DMS-4670
Mud Balance test (Tex-130-E, Part II)[1, 2]	2 per day	per PTI M55

1. Take one sample from the mixer and one sample from the farthest duct outlet.
2. Verify wet density is within the range established by the department.

Section 4.6., "Grouting." The section is voided and not replaced.

Article 5., "MEASUREMENT AND PAYMENT." The section is voided and replaced with the following.

5. **MEASUREMENT**

This Item will be measured by the each PT element or member. An element or member is defined by one of the following individual components.

- PT Cap

- PT Column
- PT Bent
- Other elements shown in the plans.

The PT may extend into other elements which is subsidiary to the main element being post-tensioned.

6. **PAYMENT**

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "PT" for the member type shown on the plans. This price is full compensation for submittals, mock-ups, prestressing steel, post-tensioning, ducts, grout fittings, grout, end anchorages, bearing plates, equipment, labor, materials, tools, and incidentals. Materials furnished for testing will not be paid for directly.

Post-tensioning of precast members, tensioned at a fabrication plant, will not be paid for directly but will be subsidiary to pertinent Items.

Special Provision to Item 427
Surface Finishes for Concrete

Item 427, "Surface Finishes for Concrete" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 427.2.1 "Coatings," is supplemented with the following:

Epoxy Waterproofing. Provide Type X Epoxy per DMS-6100 "Epoxies and Adhesives." Match color of coating with Federal Standard 595C color 35630, concrete gray, unless otherwise shown on the plans.

Article 427.4.2.2 "Application," is supplemented with the following:

Epoxy Waterproofing. Mix epoxy per manufacturer's instructions. Apply the coating on a dry surface at a maximum application rate of 100 sq. ft per gallon. Apply a thin uniform film of mixed epoxy to the substrate by the use of a short nap roller or brush. The epoxy may be sprayed following the thinning requirements of the manufacturer. No more than 15% reduction is permitted.

Match the color of the applied coating with the color standard shown on the plans. Apply when ambient temperature is between 50°F and 100°F.

Article 427.6 "Payment," the second paragraph is voided and replaced in its entirety with:

When a surface finish for concrete is specified as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Adhesive Grout Finish," "Concrete Paint Finish," "Opaque Sealer Finish," "Silicone Resin Paint Finish," "Epoxy Waterproof Finish," or "Blast Finish." This price is full compensation for materials; cleaning and preparing surfaces; application of materials; and equipment, labor, tools, and incidentals.

Special Provision to Item 438
Cleaning and Sealing Joints

Item 438, "Cleaning and Sealing Joints," of the Standard Specifications, is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

The first paragraph in Article 438.2., "Materials," the first paragraph is voided and replaced with the following:

Use sealants of the class specified on the plans that meet the requirements of DMS-6310, "Joint Sealants and Fillers" except as modified herein. Use primers recommended by the manufacturer of the sealant if required. When a foam-type joint seal is specified, provide one of the listed systems shown on the plans with material meeting the following:

- UV stable polymer impregnated foam body;
- rated for +/-50% contraction/expansion of joint opening;
- adhered to expansion joint surfaces with epoxy adhesive;
- factory attached traffic grade silicone with minimum thickness of 0.07 in. on upper surface;
- compatible field installed silicone caulk to attached silicone top to joint edges and for splicing;
- pre-compressed system for field installation; and
- provide a range of widths of joint seals to ensure the joint seal is in compression after installation is complete.

Article 438.4., "Construction," is amended by the following:

When foam-type joint seal is shown on the plans, provide a technician associated with the joint seal manufacturer for training and installation of the initial joint. Provide written instructions from the manufacturer for joint seal installation. Measure all joint openings and size the width of joint seal in accordance with manufacturer's specifications.

Article 438.6., "Payment," the second paragraph is voided and replaced by the following:

When shown as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Cleaning and Sealing Existing Joints," "Cleaning and Sealing Joints" of the class, if specified, "Cleaning and Sealing Joints (Foam)," and "Cleaning Existing Joints," and "Resizing and Sealing Joints." This price is full compensation for furnishing all materials; sawing, routing, and cleaning and installing; disposing of debris; and equipment, labor, tools, and incidentals.

Special Provision to Item 440
Reinforcement for Concrete

Item 440, "Reinforcement for Concrete," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 440.2., "Materials," is supplemented with the following.

2.7. **Welded Deformed Bar Mat Reinforcement.** Provide welded deformed bar mats in accordance with ASTM A184 except as otherwise noted in this Specification. Fabricate welded bar mats from deformed steel bars in accordance with ASTM A706 by securely connecting every intersection with a process of electrical resistance welding that employs the principle of fusion combined with pressure. The bars must be assembled by automatic machines or by other suitable mechanical means that will assure accurate spacing and alignment of all bars of the finished product.

2.14. **Zinc-Coated, Hot-Dip Galvanized Class I or Class II Steel Reinforcement.** Provide zinc-coated, hot-dip galvanized Class I or Class II steel reinforcement in accordance with ASTM A767, Grade 60 or Grade 75, when shown on the plans and as allowed.

2.15. **Continuously Hot-Dip Galvanized Reinforcement (CGR).** Provide CGR in accordance with ASTM A1094 steel reinforcement, Grade 60 or Grade 75, when shown on the plans and as allowed.

Section 440.2.1., "Approved Mills." The second paragraph is voided and not replaced.

Section 440.2.5., "Weldable Reinforcing Steel," is supplemented with the following.

All welding operations must be performed before hot-dip galvanizing.

Section 440.2.8., "Mechanical Couplers," is voided and replaced with the following.

Use couplers of the type specified in DMS-4510, "Mechanical Couplers for Reinforcing Steel," Section 4510.6.1., "General Requirements," when mechanical splices in reinforcing steel bars are shown on the plans.

Furnish only couplers pre-qualified in accordance with DMS-4510, "Mechanical Couplers for Reinforcing Steel." Ensure sleeve-wedge type couplers are not used on coated reinforcing. Sample mechanical couplers in accordance with Tex-743-I for testing before use on individual projects. Test the mechanical couplers for every project in which mechanical couplers are used in accordance with Tex-744-I. Furnish couplers only at locations shown on the plans.

Furnish couplers for stainless reinforcing steel with the same alloy designation as the reinforcing steel.

Provide hot-dip or mechanically galvanized couplers when splicing galvanized reinforcing or CGR.

Section 440.2.11., "Low Carbon/Chromium Reinforcing Steel." The first sentence is voided and replaced by the following.

Provide deformed steel bars in accordance with ASTM A1035, Grade 100, Type CS, when low-carbon, chromium-reinforcing steel is required on the plans. Type CM will be permitted only if specified on the plans.

Section 440.3.1., "Bending," is supplemented with the following.

Do not bend hot-dip galvanized reinforcement. Only minor positioning adjustments are permitted.

Bending of CGR is permitted after galvanizing.

Section 440.3.5., "Placing." The following will be added to the fourth paragraph.

Use Class 1 or Class 1A supports with CGR. Provide epoxy- or plastic-coated tie wires and clips for use with epoxy-coated reinforcing steel.

Section 440.3.6.3., "Repairing Coating," is supplemented with the following:

Repair damaged galvanized surfaces in accordance with Section 445.3.5.2., "Repair Processes."

Special Provision to Item 441
Steel Structures

Item 441, "Steel Structures" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 441.2.2., Approved Electrodes and Flux-Electrode Combinations," is voided and replaced with the following:

Use only electrodes and flux-electrode combinations conforming to AWS A5 specifications, and pertinent classifications for the applicable welding processes. When requested, submit a current Certificate of Conformance (COC) containing all test results as required by the applicable AWS A5 specification and welding code. Provide proof of Buy America compliance for welding consumables when requested. For bridge main member fabrication, submit the COC annually.

Section 441.2.3., "High-Strength Bolts," is revised and replaced by the following:

Use fasteners that meet Item 447, "Structural Bolting." Use galvanized fasteners on field connections of bridge members when ASTM F3125-Grade A325 bolts are specified, and steel is painted.

Section 441.3.1.5.1., "Plants," The second and third paragraphs are voided and replaced with the following:

Fabrication plants that produce the following non-bridge steel members must be approved in accordance with DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification."

- Item 610, "Roadway Illumination Poles"
- Item 613, "High Mast Illumination Poles"
- Item 614, "High Mast Rings and Support Assemblies"
- Item 650, "Overhead Sign Support Structures"
- Item 654, "Sign Walkways"
- Item 686, "Traffic Signal Poles"
- Special Specification 6064, "Intelligent Transportation System (ITS) Poles."

The Materials and Tests Division (MTD) maintains a list of approved non-bridge fabrication plants on the Department MPL that produce these members.

Section 441.3.1.6.1., "Erection Drawings," the third paragraph is voided and replaced with the following:

Perform erection engineering evaluation of the structural adequacy and stability of constructing the bridge system for each step of the steel erection.

Section 441.3.1.5.3., "Nondestructive Testing (NDT)," is voided and replaced with the following:

Personnel performing NDT must be qualified in accordance with the applicable AWS code and the employer's Written Practice. Level III personnel who qualifies Level I and Level II technicians must be certified by ASNT for which the NDT Level III is qualified. In addition, NDT technicians must pass hands-on tests that MTD administers. This will remain current provided they continue to perform testing on Department materials as evidenced by test reports requiring their signature. A technician who fails any of the hands-on tests must wait 3 mo. or as approved otherwise before retesting. Qualification to perform NDT will be revoked when the technician's employment is terminated or when the technician goes 6 mo. without performing a test on a Department project. The technician must pass a new hands-on test to be re-certified. Testing of similar weld joints for non-Department projects may be considered by the Engineer instead of re-testing provided enough documentation is submitted with the signature of the project's Engineer. These requirements also apply to testing agencies, and individual third-party contractors.

Section 441.3.1.5.4., "Welding Procedure Specification Qualification Testing," is voided and replaced by the following:

For Fabricators qualified in accordance with DMS-7370, DMS-7380, or DMS-7395, laboratories performing procedure qualification testing for welding procedure specifications (WPSs) must be accredited by a nationally recognized agency that performs testing in accordance with ISO/International Electrotechnical Commission (IEC) 17025 in the mechanical field of testing.

Section 441.3.1.9., "Material Identification," is amended to include the following paragraph:

Low-stress stencil marks must have a radius instead of a sharp point. Acceptable stencils include dot, vibration, and rounded-V stencils. Label these stencils so that they are easily distinguishable from other stencils that are not low-stress.

Section 441.3.2.4.1., "Flange Tilt," the last sentence is voided and replaced with the following:

Minor jacking that does not deform the material will be permitted.

Section 441.3.2.5.3., "Magnetic Particle Testing," is voided and replaced with the following:

Use alternating current (AC) when using the yoke method unless otherwise approved. Welds may be further evaluated with half-wave rectified DC for subsurface indications. Centerline cracking may be detected with aluminum prod method when approved.

Section 441.3.5.8., "Hammering," is added to state the following:

Do not perform hammering on any portion of the member that causes the material to permanently deform. Avoid damage to the material by measures such as use of brass or aluminum hammers or by padding the area to be hammered.

Section 441.3.8.1., "Shop Painting," is amended to include with the following paragraph:

Measure the anchor profile after blast cleaning at random locations along the thermal cut surfaces. If specified anchor profile is not achieved over the entire flame cut surface, grind the edges and re-blast to achieve the required anchor pattern.

Section 441.3.9., "Handling and Storage of Materials," The second sentence of the second paragraph is replaced by the following:

Keep materials clean and avoid damaging of the applied coating.

Special Provision to Item 442
Metal for Structures

Item 442, "Metal for Structures" of the Standard Specifications is amended with respect to the clause cited below. No other clauses or requirements of this Item are waived or changed.

Section 442.2.1.3.3., "Fasteners." The first sentence of the first paragraph is replaced by the following:

Fasteners. Provide high-strength bolts that meet ASTM F3125-Grade A325 unless otherwise shown on the plans.

Section 442.2.1.3.3., "Fasteners." The third paragraph is deleted and not replaced.

Special Provision to Item 446
Field Cleaning and Painting Steel

For this project, Item 446, "Field Cleaning and Painting Steel," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Section 446.4.1., "Qualification," the first and second paragraphs are voided and replaced by the following:

> Submit to the Engineer documentation verifying SSPC QP 1 or NACE NIICAP AS-1 certification for work requiring the removal or application of coatings. Additionally, submit to the Engineer documentation verifying SSPC QP 2 Cat A or NACE NIICAP AS-2 certification when work requires removal of coatings containing hazardous materials. Maintain certifications throughout the project. No work may be performed without current and active certifications unless otherwise shown on the plans. The Engineer may waive certification requirements for minor, touch-up repair work and coating steel members repaired in accordance with Item 784, "Steel Member Repair."
>
> The Engineer may waive certification requirements, when stated on the plans, for the purpose of qualification in either contractor certification program if the project has been accepted as a qualification project as part of the process for obtaining SSPC QP1 Cat A or NACE NIICAP AS-1 certification. Submit certification applications and proof of acceptance before beginning work or provide SSPC QP 7 certification when required on the plans.

Section 446.4.7.3.2., "Classes of Cleaning," is amended with the following:

> Prepare all surfaces of painted steel members subsequently exposed from structural operations, such as deck removal or steel repair, in accordance with this Item. Prevent loose or damaged paint from entering the environment.

Special Provision to Item 448
Structural Field Welding

Item 448, "Structural Field Welding" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 448.2., "Materials," the third paragraph is voided and replaced with the following:

Use only electrodes and flux-electrode combinations conforming to AWS A5 specifications and pertinent classifications for the applicable welding processes. When requested, submit a current Certificate of Conformance (COC) containing acceptable wording indicating Buy America compliance and all tests required by the applicable AWS specifications and welding codes. Tests must be conducted on electrodes of the same class, size, and brand; and manufactured by the same process and with the same materials as the electrodes to be furnished.

Special Provision to Item 449
Anchor Bolts

Item 449, "Anchor Bolts" of the Standard Specifications is amended with respect to the clause cited below. No other clauses or requirements of this Item are waived or changed.

Section 449.2.1., "Bolts and Nuts." Table 1 is replaced by the following:

Table 1
Bolt and Nut Standards

Specified Anchor Bolt Category	Bolt Standards	Nut Standards
Mild steel	ASTM A307 Gr. A, F1554 Gr. 36, or A36	ASTM A563
Medium-strength, mild steel	ASTM F1554 Gr. 55 with supplementary requirement S1	ASTM A194 Gr. 2 or A563 Gr. D or better
High-strength steel	ASTM F3125-Grade A325 or ASTM A449[1]	ASTM A194 or A563, heavy hex
Alloy steel	ASTM A193 Gr. B7 or F1554 Gr. 105	ASTM A194 Gr. 2H or A563 Gr. DH, heavy hex

1. **If headed bolts are specified, ASTM A449 bolts must be heavy hex head.**

Section 449.3.3.1,"Anchor Bolt Thread Lubricant Coating," The first sentence of the first paragraph is voided and replaced by the following.

Coat anchor bolt threads before installing nuts with an electrically conducting lubricant compound described in Section 449.3.3.2.1., "Definitions," for traffic signal poles, roadway illumination poles, high mast illumination poles, intelligent transportation system poles, overhead sign support structures, and steel electrical service supports.

Section 449.3.3.2,"Anchor Bolt Tightening Procedure," The first sentence of the first paragraph is voided and replaced by the following.

Tighten anchor bolts for traffic signal poles, shoe base and concrete traffic barrier base roadway illumination poles, high mast illumination poles, intelligent transportation system poles, and overhead sign support structures in accordance with this Section.

Special Provision to Item 462
Concrete Box Culverts and Drains

Item 462, "Concrete Box Culverts and Drains," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Section 2.1., "General." The last paragraph is voided and replaced with the following:

Furnish material for precast formed and machine-made box culverts in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures."

Sections 2.2.2., "Formed Precast," and 2.2.3., "Machine-Made Precast," are voided and replaced by the following.

2.2.2 **Precast.** Precast formed and machine –made box culvert fabrication plants must be approved in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures." The Construction Division maintains a list of approved precast box culvert fabrication plants on the Department's MPL. Fabricate precast boxes in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures."

Sections 2.3.2., "Formed Precast," and 2.3.3., "Machine-Made Precast," are voided and replaced by the following.

2.3.2 **Precast.** Make, cure, and test compressive test specimens for precast formed and machine –made box culverts in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures.

Section 2.5., "Marking," the first paragraph is voided and replaced with the following.

Marking. Clearly mark each precast unit with the following:

- Name or trademark of fabricator and plant location;
- ASTM designation and product designation (when applicable);
- Date of manufacture,
- Box size,
- Minimum and maximum fill heights,
- Designation "TX" for precast units fabricated per DMS-7305,
- Fabricator's designated approval stamp for each approved unit,
- Designation "SR" for boxes meeting sulfate-resistant concrete plan requirements (when applicable), and
- Precast drainage structures used for jacking and boring (when applicable).

Section 2.6., "Tolerances." The section is voided and replaced with the following.

Ensure precast sections meet the permissible variations listed in ASTM C1577.

Ensure that the sides of a section at each end do not vary from being perpendicular to the top and bottom by more than 1/2 in. when measured diagonally between opposite interior corners. Deviations from this tolerance will be acceptable if the sections can be fitted at the plant and the joint opening at any point does not exceed 1 in. Use match-marks for proper installation on sections that have been accepted in this manner.

Ensure wall and slab thicknesses are not less than shown on the plans except for occasional deficiencies not greater than 3/16 in. or 5%, whichever is greater. If proper jointing is not affected, thicknesses in excess of plan requirements are acceptable.

Section 2.7., "Defects and Repair." The section is voided and replaced with the following:

Fine cracks on the surface of members that do not extend to the plane of the nearest reinforcement are acceptable unless the cracks are numerous and extensive. Repair cracks that extend into the plane of the reinforcing steel in accordance with the Department's Concrete Repair Manual. The Engineer may accept boxes with repairs that are sound, properly finished, and cured in conformance with pertinent specifications. Discontinue further production of precast sections until corrections are made and proper curing is provided when fine cracks on the surface indicate poor curing practices.

Repair precast boxes in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures."

Section 2.8., "Storage and Shipment." This section is voided and replaced with the following:

2.8 **Storage and Shipment.** Store precast sections on a level surface. Do not place any load on the sections until design strength is reached and curing is complete. Store and ship precast boxes in accordance with DMS-7305, "Fabrication and Qualification Production for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures.

Special Provision to Item 464
Reinforced Concrete Pipe

Item 464, "Reinforced Concrete Pipe," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Section 2.1., "Fabrication." The section is voided and replaced with the following.

Fabrication plants must be approved by the Materials and Tests Division in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures," before furnishing precast reinforced concrete pipe for Departmental projects. The Department's MPL has a list of approved reinforced concrete pipe plants.

Furnish material and fabricate reinforced concrete pipe in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures."

Section 2.3., "Marking." The first paragraph is voided and replaced with the following.

Furnish each section of reinforced concrete pipe marked with the following information specified in DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures."

- Class or D-Load of pipe,
- ASTM designation,
- Date of manufacture,
- Pipe size,
- Name or trademark of fabricator and plant location,
- Designation "TX" for precast units fabricated per DMS-7305;
- Designated fabricator's approval stamp for each approved unit,
- Pipe to be used for jacking and boring (when applicable), and
- Designation "SR" for pipe meeting sulfate-resistant concrete plan requirements (when applicable).

Section 2.5., "Causes for Rejection." The section is voided and replaced with the following.

Individual sections of pipe may be rejected for any of the conditions stated in the Annex of DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures."

Section 2.6., "Repairs." The section is voided and replaced with the following:

Make repairs, if necessary, as stated in the Annex of DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures."

Special Provision to Item 465
Junction Boxes, Manholes, and Inlets

Item 465, "Junction Boxes, Manholes, and Inlets," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Section 2.1., "Concrete," The section is voided and replaced with the following.

Furnish concrete per DMS-7305 for formed and machine-made precast junction boxes, manholes, and inlets. Furnish Class C concrete for cast-in-place junction boxes, manholes, and inlets unless otherwise shown on the plans.

Section 3.1., "Precast Junction Boxes, Manholes, and Inlets," The section is voided and replaced with the following.

Construct formed and machine-made precast junction boxes, manholes, and inlets in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures" and the Contract Plans, except as otherwise noted in this Item.

Multi-project fabrication plants as defined in Item 424 "Precast Concrete Structural Members (Fabrication)," that produce junction boxes, manholes, and inlets will be approved by the Materials and Tests Division in accordance with DMS-7305, "Fabrication and Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Drainage Structures." The Department's MPL has a list of approved multi-project fabrication plants.

Section 3.1.1., "Lifting Holes," The section is voided and not replaced.

Section 3.1.2., "Marking." The section is voided and replaced with the following.

Marking. Clearly mark each precast junction box, manhole, and inlet unit with the following information:

- name or trademark of fabricator and plant location;
- product designation;
- ASTM designation (if applicable);
- date of manufacture;
- designation "TX" for precast units fabricated per DMS-7305;
- designated fabricator's approval stamp for each approved unit; and
- designation "SR" for product meeting sulfate-resistant concrete plan requirements (when applicable).

Special Provision to Item 502
Barricades, Signs and Traffic Handling

Item 502, "Barricades, Signs and Traffic Handling" of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Article 502.1., "Description," is supplemented by the following:

Temporary work-zone (TWZ) traffic control devices manufactured after December 31, 2019, must have been successfully tested to the crashworthiness requirements of the 2016 edition of the Manual for Assessing Safety Hardware (MASH). Such devices manufactured on or before this date and successfully tested to NCHRP Report 350 or the 2009 edition of MASH may continue to be used throughout their normal service lives. An exception to the manufacture date applies when, based on the project's date of letting, a category of MASH-2016 compliant TWZ traffic control devices are not approved, or are not self-certified after the December 31, 2019, date. In such case, devices that meet NCHRP-350 or MASH-2009 may be used regardless of the manufacture date.

Such TWZ traffic control devices include: portable sign supports, barricades, portable traffic barriers designated exclusively for use in temporary work zones, crash cushions designated exclusively for use in temporary work zones, longitudinal channelizers, truck and trailer mounted attenuators. Category I Devices (i.e., lightweight devices) such as cones, tubular markers and drums without lights or signs attached however, may be self-certified by the vendor or provider, with documentation provided to Department or as are shown on Department's Compliant Work Zone Traffic Control Device List.

Article 502.4., "Payment," is supplemented by the following:

Truck mounted attenuators and trailer attenuators will be paid for under Special Specification, "Truck Mounted Attenuator (TMA) and Trailer Attenuator (TA)." Portable Changeable Message Signs will be paid for under Special Specification, "Portable Changeable Message Sign." Portable Traffic Signals will be paid for under Special Specification, "Portable Traffic Signals."

Special Provision to Item 506

Temporary Erosion, Sedimentation, and Environmental Controls

Item 506, "Temporary Erosion, Sedimentation, and Environmental Controls," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 506.1., "Description." The second paragraph is voided and replaced by the following.

Contractor is considered primary operator to have day-to-day operational control as defined in TPDES GP TXR150000.

1.1. For projects with soil disturbance of less than 1 acre, no submittal to TCEQ will be required but Contractor will follow SWP3. For projects with soil disturbance of 1acre to less than 5 acres a small site notice will be posted at the site. For projects with soil disturbance of 5 acres or more a Notice of Intent (NOI) is required and a large site notice posted at site. Postings will be in accordance with TPDES GP TXR150000. Postings not associated with project specific locations will be in same location as Department's postings.

1.2. Notice of Intent (NOI). Submit a NOI, if applicable, with the TCEQ under the TPDES GP TXR150000 at least 7 days prior to commencement of construction activities at the project site. Provide a signed copy to the Engineer and any other MS4 operators at the time of submittal. The Department will submit their NOI prior to contractor submission and will provide a copy for Contractor's use in completing the Contractor's NOI form.

1.3. Notice of Change (NOC). Upon concurrence of the Engineer, submit a NOC, if applicable, to the TCEQ within 14 days of discovery of a change or revision to the NOI as required by the TPDES GP TXR150000. Provide a signed copy of the NOC to the Engineer and any other MS4 operators at the time of submittal.

1.4. Notice of Termination (NOT). Upon concurrence of the Engineer, submit a NOT, if applicable, to the TCEQ within 30 days of the Engineer's approval that 70% native background vegetative cover is met or equivalent permanent stabilization have been employed in accordance with the TPDES GP TXR 150000. Provide a signed copy of the NOT to the Engineer and any other MS4 operators at the time of submittal.

Section 506.3.1, "Contractor Responsible Person Environmental (CRPE) Qualifications and Responsibilities," is supplemented by the following:

3.1. Contractor Responsible Person Environmental (CRPE) Qualifications and Responsibilities. Provide and designate in writing at the preconstruction conference a CRPE and alternate CRPE who have overall responsibility for the storm water management program. The CRPE will implement stormwater and erosion control practices; will oversee and observe stormwater control measure monitoring and management; will monitor the project site daily and produce daily monitoring reports as long as there are BMPs in place or soil disturbing activities are evident to ensure compliance with the SWP3 and TPDES General Permit TXR150000. Daily monitor reports shall be maintained and made available upon request. During time suspensions when work is not occurring or on contract non-work days, daily inspections are not required unless a rain event has occurred. The CRPE will provide recommendations on how to improve the effectiveness of control measures. Attend the Department's preconstruction conference for the project. Ensure training is completed as identified in Section 506.3.3., "Training," by all applicable personnel before employees work on the project. Document and maintain and make available upon request, a list, signed by the CRPE, of all applicable Contractor and subcontractor employees who have completed the training. Include the employee's name, the training course name, and date the employee completed the training.

Section 506.3.3., "Training," is supplemented by the following:

Training is provided by the Department at no cost to the Contractor and is valid for 3 yr. from the date of completion. The Engineer may require the following training at a frequency less than 3 yr. based on environmental needs:

- "Environmental Management System: Awareness Training for the Contractor" (English and Spanish) (Approximate running time 20 min.), and
- "Storm Water: Environmental Requirements During Construction" (English and Spanish) (Approximate running time 20 min.).

The Contractor responsible person environmental (CRPE), alternate CRPE designated for emergencies, Contractor's superintendent, Contractor, and subcontractor lead personnel involved in soil disturbing or SWP3 activities must enroll in and complete the training listed below and maintain and make available upon request the certificate of completion. Training is provided by a third party and is valid for 3 yr. from the date shown on the Certificate of Completion. Coordinate enrollment as prescribed by the Department and pay associated fees for the following training:

- "Revegetation During Construction,"
- "Construction General Permit Compliance," and
- "Construction Stage Gate Checklist (CSGC)."

Training and associated fee will not be measured or paid for directly but are subsidiary to this Item.

Special Provision to Item 520
Weighing and Measuring Equipment

Item 520, "Weighing and Measuring Equipment" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 520.2., "Equipment." The third paragraph is voided and replaced by the following.

Calibrate truck scales using weights certified by the Texas Department of Agriculture (TDA) or an equivalent agency as approved. Provide a written calibration report from a scale mechanic for truck scale calibrations. Cease plant operations during the checking operation. Do not use inaccurate or inadequate scales. Bring performance errors as close to zero as practicable when adjusting equipment.

Article 520.2., "Equipment." The fourth paragraph is amended to include the following:

At the Contractors option, an electronic ticket delivery system (e-ticketing) may be used instead of printed tickets. The use of e-ticketing will require written approval of the Engineer. At a minimum, the approved system will:

- Provide electronic, real-time e-tickets meeting the requirements of the applicable bid items;
- Automatically generate e-tickets using software and hardware fully integrated with the automated scale system used to weigh the material, and be designed in such a way that data input cannot be altered by the Contractor or the Engineer;
- Provide the Engineer access to the e-ticketing data in real-time with a web-based or app-based system compatible with iOS;
- Provide offline capabilities to prevent data loss if power or connectivity is lost;
- Require both the Contractor and the Engineer to accept or reject the e-ticket and provide the ability to record the information required by the applicable bid items, as well as any comments. Record the time of the approval/rejection and include it in the summary spreadsheet described below. Provide each party the capability to edit their respective actions and any entered information;

The Contractor may discontinue use of the e-ticket system and provide printed tickets as needed to meet the requirements of the applicable bid items.

Special Provision to Item 540
Metal Beam Guard Fence

Item 540, "Metal Beam Guard Fence" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 540.4.7, "Measurement," is voided and replaced with the following:

> **Long Span System**. Measurement will be by each long span system, complete in place. Each long span system will be from the first CRT to the last CRT in the system.

Special Provision to Item 656
Foundations for Traffic Control Devices

Item 656, "Foundations for Traffic Control Devices" of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Article 3. "Construction.," the first paragraph is supplemented by the following:

Ensure the top of the foundation and anchor bolts meet specified requirements in relation to the final grade.

Special Provision to Item 666
Retroreflectorized Pavement Markings

Item 666, "Retroreflectorized Pavement Markings," of the Standard Specifications is amended with respect to the clauses cited below. No other clauses or requirements of this Item are waived or changed.

Section 2.3., "Glass Traffic Beads." The first paragraph is voided and replaced by the following:

Furnish drop-on glass beads in accordance with DMS-8290, "Glass Traffic Beads," or as approved. Furnish a double-drop of Type II and Type III drop-on glass beads for longitudinal pavement markings where each type bead is applied separately in equal portions (by weight), unless otherwise approved. Apply the Type III beads before applying the Type II beads. Furnish Type II beads for work zone pavement markings and transverse markings or symbols.

Section 4.3.1., "Type I Markings.," is supplemented by the following:

4.3.1.3. Spot Striping. Perform spot striping on a callout basis with a minimum callout quantity as shown on the plans.

Section 4.3.2., "Type II Markings.," is supplemented by the following:

4.3.2.1. Spot Striping. Perform spot striping on a callout basis with a minimum callout quantity as shown on the plans.

Section 4.4., "Retroreflectivity Requirements.," is voided and replaced by the following.

Type I markings for Contracts totaling more than 20,000 ft. of pavement markings must meet the following minimum retroreflectivity values for all longitudinal edgeline, centerline or no passing barrier-line, and lane line markings when measured any time after 3 days, but not later than 10 days after application.

- White markings: 250 millicandelas per square meter per lux (mcd/m^2/lx)
- Yellow markings: 175 mcd/m^2/lx

Retroreflectivity requirements for Type I markings are not required for Contracts with less than 20,000 ft. of pavement markings or Contracts with callout work, unless otherwise shown on the plans.

Section 4.5., "Retroreflectivity Measurements.," is voided and replaced by the following:

Use a mobile retroreflectometer to measure retroreflectivity for Contracts totaling more than 50,000 ft. of pavement markings, unless otherwise shown on the plans. For Contracts with less than 50,000 ft. of pavement markings, mobile or portable retroreflectometers may be used at the Contractor's discretion. Coordinate with and obtain authorization from the Engineer before starting any retroreflectivity data collection.

Section 4.5.1., "Mobile Retroreflectometer Measurements." The last paragraph is voided and replaced by the following.

Restripe again at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements falls below the minimum retroreflectivity requirements. Take measurements every 0.1 miles a minimum of 10 days after this third application within that mile segment for that series of markings. If the markings do not meet minimum retroreflectivity after this third application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

Section 4.5.2., "Portable Retroreflectometer Measurements." The first and second paragraphs are voided and replaced by the following.

Provide portable measurement averages for every 1.0 mile unless otherwise specified or approved. Take a minimum of 20 measurements for each 1-mi. section of roadway for each series of markings (e.g., edgeline, center skip line, each line of a double line) and direction of traffic flow when using a portable reflectometer. Measure each line in both directions for centerlines on two-way roadways (i.e., measure both double solid lines in both directions and measure all center skip lines in both directions). The spacing between each measurement must be at least 100 ft. The Engineer may decrease the mileage frequency for measurements if the previous measurements provide satisfactory results. The Engineer may require the original number of measurements if concerns arise.

Restripe at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the averages of these measurements fail. Take a minimum of 10 more measurements after 10 days of this second application within that mile segment for that series of markings. Restripe again at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements falls below the minimum retroreflectivity requirements. If the markings do not meet minimum retroreflectivity after this third application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

Section 4.6. "Performance Period." The first sentence is voided and replaced by the following:

All longitudinal markings must meet the minimum retroreflectivity requirements within the time frame specified. All markings must meet all other performance requirements of this specification for at least 30 calendar days after installation.

Article 6. "Payment." The first two paragraphs are voided and replaced by the following.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pavement Sealer" of the size specified; "Retroreflectorized Pavement Markings" of the type and color specified and the shape, width, size, and thickness (Type I markings only) specified, as applicable; "Retroreflectorized Pavement Markings with Retroreflective Requirements" of the types, colors, sizes, widths, and thicknesses specified; "Retroreflectorized Profile Pavement Markings" of the various types, colors, shapes, sizes, and widths specified; or "Reflectorized Pavement Marking (Call Out)" of the shape, width, size, and thickness (Type I markings only) specified, as applicable; or "Pavement Sealer (Call Out)" of the size specified.

This price is full compensation for materials, application of pavement markings, equipment, labor, tools, and incidentals.

Special Provision to Item 672
Raised Pavement Markings

For this project, Item 672, "Raised Pavement Markings," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Article 672.3., "Construction," the twelfth paragraph is voided and replaced by the following:

Provide a 30-day performance period that begins the day following written acceptance for each separate location or patch. The date of written acceptance will be the last calendar day of each month for the RPMs installed that month for the completed separate project locations. This written acceptance does not constitute final acceptance.

Article 672.3., "Construction," is supplemented by the following:

672.3.1. Raised Pavement Markers Patch. Raised Pavement Markers will be in accordance with Item 672, "Raised Pavement Markers." Unless otherwise directed in the General Notes and Specification Data, a patch will be defined as 1,000 LF or less along the center line of the roadway. The Engineer will determine whether to remove and place markers on the entire roadway segment or just the patch areas. Unless otherwise directed on the plans, the Contractor will remove temporary pavement markings (tabs or temporary tape) prior to placement of permanent markers.

Article 672.5., "Payment," the first paragraph is voided and replaced by the following:

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid for "Reflectorized Pavement Marker," "Traffic Button," "Plowable Reflectorized Pavement Marker," or "Reflectorized Pavement Marker (Patch)" of the types specified.

RPMs INSTALLATION RECORD

The 30-day performance period begins the day after written acceptance for each separate location. The date of written acceptance will be the last calendar day of each month for the RPMs installed that month for the completed separate project locations.

COUNTY HIGHWAY	CONTROL PROJECT	LIMITS FROM LIMITS TO	MONTH/YR OF INSTALLATION

Contractor signature _____ _____
Date

Department signature _____ _____
Date

Special Provision to Special Specification 3096 Asphalts, Oils, and Emulsions

Special Specification 3096, "Asphalts, Oils, and Emulsions," is amended with respect to the clause cited below. No other clause or requirements of this Item are waived or changed.

Sections 3096.2.1, "Asphalt Cement," 2.3., "Cutback Asphalt," 2.4., Emulsified Asphalt," and 2.5., "Specialty Emulsions," "Solubility in trichloroethylene, %" in Tables 2, 4-10, 10A, 10C, 11, and 11A have been replaced with "Solubility, %".

Section 3096.2.2., "Polymer-Modified Asphalt Cement," Table 3, "Polymer-Modified Asphalt Cement," has been voided and replaced by the following:

Table 3
Polymer-Modified Asphalt Cement

Property	Test Procedure	Polymer-Modified Viscosity Grade											
		AC-12-5TR		NT-HA[1]		AC-15P		AC-20XP		AC-10-2TR		AC-20-5TR	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Polymer		TR		–		SBS		SBS		TR		TR	
Polymer content, % (solids basis)	Tex-533-C or Tex-553-C	5.0	–	–	–	3.0	–	–	–	2.0	–	5.0	–
Dynamic shear, G*/sin δ, 82°C, 10 rad/s, kPa	T 315	–	–	1.0	–	–	–	–	–	–	–	–	–
Dynamic shear, G*/sin δ, 64°C, 10 rad/s, kPa	T 315	–	–	–	–	–	–	1.0	–	–	–	1.0	–
Dynamic shear, G*/sin δ, 58°C, 10 rad/s, kPa	T 315	1.0	–	–	–	–	–	–	–	1.0	–	–	–
Viscosity													
140°F, poise	T 202	1,200	–	–	–	1,500	–	2,000	–	1,000	–	2,000	–
275°F, poise	T 202	–	–	–	–	–	8.0	–	–	–	8.0	–	10.0
275°F, Pa-s	T 316	–	–	–	4.0	–	–	–	–	–	–	–	–
Penetration, 77°F, 100 g, 5 sec.	T 49	110	150	–	25	100	150	75	115	95	130	75	115
Elastic recovery, 50°F, %	Tex-539-C	55				55	–	55	–	30	–	55	–
Polymer separation	Tex-540-C	None		–		None		None		None		None	
Flash point, C.O.C., °F	T 48	425		425		425	–	425	–	425	–	425	–
Tests on residue from RTFOT aging and pressure aging:	T 240 and R 28												
Creep stiffness	T 313												
S, -18°C, MPa		–	300	–	–	–	300	–	300	–	300	–	300
m-value, -18°C		0.300	–	–	–	0.300	–	0.300	–	0.300	–	0.300	–

1. This is a hot-applied TRAIL product.

Section 3096.2.5.1., "Diluted Emulsions," added Section and tables.

Diluted Emulsions. Provide emulsified asphalt that is homogeneous, does not separate after thorough mixing, and meets the requirements for the specified type and grade in Tables 12A, and 12B, where the suffixes 50/50, 40/60, and 30/70 mean 50% emulsion diluted with 50% water; 40% emulsion diluted with 60% water, and 30% emulsion diluted with 70% water, respectively.

For example, CSS-1H 40/60 means 40% CSS-1H diluted with 60% water and AE-P 30/70 means 30% AE-P diluted with 70% water.

Table 12A
Diluted CSS-1H

Property	Test Procedure	Type-Grade					
		Diluted Slow-Setting					
		CSS-1H 50/50		CSS-1H 40/60		CSS-1H 30/70	
		Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol 77°F, sec.	T 72	Report Only		Report Only		Report Only	
Distillation test:							
Residue by distillation, % by wt.	T 59	30	–	24	–	18	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	0.5
Tests on residue from distillation:							
Penetration, 77°F, 100 g, 5 sec.	T 49	40	110	40	110	40	110
Solubility, %	T 44	97.5	–	97.5	–	97.5	–
Ductility, 77°F, 5 cm/min., cm	T 51	80	–	80	–	80	–

Table 12B
Diluted AE-P

Property	Test Procedure	Type–Grade					
		Diluted Slow-Setting					
		AE-P 50/50		AE-P 40/60		AE-P 30/70	
		Min	Max	Min	Min	Max	Min
Viscosity, Saybolt Furol 122°F, sec.	T 72	Report Only		Report Only		Report Only	
Asphalt emulsion distillation to 500°F followed by Cutback asphalt distillation of residue to 680°F:	T 59 & T 78						
Residue after both distillations, % by wt.		20	–	16	–	12	–
Total oil distillate from both distillations, % by volume of emulsion		12.5	20	10.0	16	7.5	12
Tests on residue after all distillations:							
Solubility, %	T 44	97.5	–	97.5	–	97.5	–
Float test, 122°F, sec.	T 50	50	200	50	200	50	200

Section 2.10., "Performance-Graded Binders." This section has been voided and replaced by the following.

2.10. Performance-Graded Binders. Provide PG binders that are smooth and homogeneous, show no separation when tested in accordance with Tex-540-C, and meet the requirements shown in Table 17.

Separation testing is not required if:

- a modifier is introduced separately at the mix plant by injection in either the asphalt line or mixer,
- the binder is blended onsite in continuously agitated tanks, or
- binder acceptance is based on field samples taken from an in-line sampling port at the hot-mix plant after the addition of modifiers.

Table 17
Performance-Graded Binders

Property and Test Method	Performance Grade																		
	PG 58			PG 64				PG 70				PG 76				PG 82			
	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	
Average 7-day max pavement design temperature, °C[1]	58			64				70				76				82			
Min pavement design temperature, °C[1]	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	
Original Binder																			
Flash point, T 48, Min, °C	230																		
Viscosity, T 316[2, 3]: Max, 3.0 Pa·s, test temperature, °C	135																		
Dynamic shear, T 315[4]: G*/sin(δ), Min, 1.00 kPa, Max, 2.00 kPa[5], Test temperature @ 10 rad/sec., °C	58			64				70				76				82			
Elastic recovery, D6084, 50°F, % Min[6]	–	–	30	–	–	30	50	–	30	50	60	30	50	60	70	50	60	70	
Rolling Thin-Film Oven (RTFO) (T 240)																			
Mass change, T 240, Max, %	1.0																		
Dynamic shear, T 315: G*/sin(δ), Min, 2.20 kPa, Max, 5.00 kPa[5], Test temperature @ 10 rad/sec., °C	58			64				70				76				82			
MSCR, T350, Recovery, 0.1 kPa, High Temperature, % Min[6]	–	–	20	–	–	20	30	–	20	30	40	20	30	40	50	30	40	50	
Pressure Aging Vessel (PAV) Residue (R 28)																			
PAV aging temperature, °C	100																		
Dynamic shear, T 315 G*sin(δ), Max, 5,000 kPa (Max, 6,000 kPa for δ ≥42°) Test temperature @ 10 rad/sec., °C	25	22	19	28	25	22	19	28	25	22	19	28	25	22	19	28	25	22	
Creep stiffness, T 313[7, 8]: S, max, 300 MPa, m-value, Min, 0.300 Test temperature @ 60 sec., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	
Direct tension, T 314[8] Failure strain, Min, 1.0% Test temperature @ 1.0 mm/min., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	

1. Pavement temperatures are estimated from air temperatures and using an algorithm contained in a Department-supplied computer program, may be provided by the Department, or may be obtained following the procedures outlined in AASHTO MP 323 and R 25.
2. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. At test temperatures where the binder is a Newtonian fluid, any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
3. Viscosity at 135°C is an indicator of mixing and compaction temperatures that can be expected in the lab and field. High values may indicate high mixing and compaction temperatures. Additionally, significant variation can occur from batch to batch. Contractors should be aware that variation could significantly impact their mixing and compaction operations. Contractors are therefore responsible for addressing any constructability issues that may arise.
4. For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be substituted for dynamic shear measurements of G*/sin(δ) at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
5. Max values for unaged and RTFO-aged dynamic shear apply only to materials used as substitute binders, as described in Item 341, "Dense-Graded Hot-Mix Asphalt," and Item 344, "Superpave Mixtures."
6. Elastic recovery (D6084) is not required unless MSCR (T 350) is less than the Min % recovery. Elastic recovery will be used for the acceptance criteria in this instance.
7. Silicone beam molds, as described in AASHTO TP 1-93, are acceptable for use.
8. If creep stiffness is below 300 MPa, direct tension test is not required. If creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m value requirement must be satisfied in both cases.

Special Provision to Special Specification 6185
Truck Mounted Attenuator (TMA) and Trailer Attenuator (TA)

Item 6185, "Truck Mounted Attenuator (TMA) and Trailer Attenuator (TA)" of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

Article 4. "Measurement", is voided and replaced by the following:

4.1. **Truck Mounted Attenuator/Trailer Attenuator (Stationary).** This Item will be measured by the day. TMA/TAs must be set up in a work area and operational before a calendar day can be considered measureable. A day will be measured for each TMA/TA set up and operational on the worksite.

4.2. **Truck Mounted Attenuator/Trailer Attenuator (Mobile Operation).** This Item will be measured by the hour or by the day. The time begins once the TMA/TA is ready for operation at the predetermined site and stops when notified by the Engineer. When measurement by the hour is specified, a minimum of 4 hr. will be paid each day for each operating TMA/TA used in a mobile operation. When measurement by the day is specified, a day will be measured for each TMA/TA set up and operational on the worksite.

Special Specification 3076
Dense-Graded Hot-Mix Asphalt

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant. Payment adjustments will apply to HMA placed under this specification unless the HMA is deemed exempt in accordance with Section 3076.4.9.4., "Exempt Production."

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate**. Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Aggregate from reclaimed asphalt pavement (RAP) is not required to meet Table 1 requirements unless otherwise shown on the plans. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. **Coarse Aggregate**. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates**. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials, unless otherwise shown on the plans. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement unless otherwise shown on the plans. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Coarse aggregate from RAP and Recycled Asphalt Shingles (RAS) will be considered as Class B aggregate for blending purposes.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.1.2. **Micro-Deval Abrasion**. The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
$MD_{act.}$ = actual Micro-Deval percent loss
RSMD = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Soils and Aggregates Section of the Materials and Tests Division, and additional testing may be required before granting approval.

2.1.2. **Intermediate Aggregate**. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used that are free from organic impurities. The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

2.1.3. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Unless otherwise shown on the plans, up to 10% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.5
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note 1
Los Angeles abrasion, %, Max	Tex-410-A	40
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	30
Crushed face count,[2] %, Min	Tex-460-A, Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Sand equivalent, %, Min	Tex-203-F	45

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 3076.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler**. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3, unless otherwise shown on the plans.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

2.3. **Baghouse Fines**. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. **Asphalt Binder**. Furnish the type and grade of performance-graded (PG) asphalt specified on the plans.

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized tack coat materials listed on the Department's MPL are allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

2.6. **Additives**. Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing, compaction, or improve the quality of the mixture are allowed when approved. Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

2.6.1. **Lime and Liquid Antistripping Agent**. When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.6.2. **Warm Mix Asphalt (WMA)**. Warm Mix Asphalt (WMA) is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using approved WMA additives or processes from the Department's MPL.

WMA is allowed for use on all projects and is required when shown on the plans. When WMA is required, the maximum placement or target discharge temperature for WMA will be set at a value below 275°F.

Department-approved WMA additives or processes may be used to facilitate mixing and compaction of HMA produced at target discharge temperatures above 275°F; however, such mixtures will not be defined as WMA.

2.6.3. **Compaction Aid.** Compaction Aid is defined as a chemical warm mix additive that is used to produce an asphalt mixture at a discharge temperature greater than 275°F.

Compaction Aid is allowed for use on all projects and is required when shown on the plans.

2.7. **Recycled Materials**. Use of RAP and RAS is permitted unless otherwise shown on the plans. Use of RAS is restricted to only intermediate and base mixes unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages shown in Table 4 may be decreased or increased when shown on the plans. Determine the asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F, Part I. The Engineer may verify the asphalt binder content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 5 during mixture design and HMA production when RAP or RAS is used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes referenced in Tables 4 and 5 are defined as follows:

- **Surface**. The final HMA lift placed at the top of the pavement structure or placed directly below mixtures produced in accordance with Items 316, 342, 347, or 348;
- **Intermediate**. Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. from the riding surface; and
- **Base**. Mixtures placed greater than 8.0 in. from the riding surface. Unless otherwise shown on the plans, mixtures used for bond breaker are defined as base mixtures.

2.7.1. **RAP**. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Fractionated RAP is defined as a stockpile that contains RAP material with a minimum of 95.0% passing the 3/8-in. or 1/2-in. sieve, before burning in the ignition oven, unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in. or 1/2-in. screen to fractionate the RAP.

Use of Contractor-owned RAP including HMA plant waste is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than 8. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Maximum Allowable Amounts of RAP[1]

Maximum Allowable Fractionated RAP (%)		
Surface	**Intermediate**	**Base**
15.0	25.0	30.0

1. Must also meet the recycled binder to total binder ratio shown in Table 5.

2.7.2. **RAS**. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is not permitted in surface mixtures unless otherwise shown on the plans. RAS may be used in intermediate and base mixtures unless otherwise shown on the plans. Up to 3% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements of Table 1 and Table 2 or fine RAP to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 3.0% of the HMA mixture in accordance with Table 4.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if it has not come into contact with any hazardous materials. Use RAS from shingle sources on the Department's MPL. Remove substantially all materials before use that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

2.8. **Substitute Binders**. Unless otherwise shown on the plans, the Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified, if using recycled materials, and if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.10., "Performance-Graded Binders;" and
- the mixture has less than 10.0 mm of rutting on the Hamburg Wheel test (Tex-242-F) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg Wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

Originally Specified PG Binder	Allowable Substitute PG Binder for Surface Mixes	Allowable Substitute PG Binder for Intermediate and Base Mixes	Maximum Ratio of Recycled Binder[1] to Total Binder (%)		
			Surface	Intermediate	Base
76-22[4,5]	70-22	70-22	10.0	20.0	25.0
70-22[2,5]	N/A	64-22	10.0	20.0	25.0
64-22[2,3]	N/A	N/A	10.0	20.0	25.0
76-28[4,5]	70-28	70-28	10.0	20.0	25.0
70-28[2,5]	N/A	64-28	10.0	20.0	25.0
64-28[2,3]	N/A	N/A	10.0	20.0	25.0

1. Combined recycled binder from RAP and RAS. RAS is not permitted in surface mixtures unless otherwise shown on the plans.
2. Binder substitution is not allowed for surface mixtures.
3. Binder substitution is not allowed for intermediate and base mixtures.
4. Use no more than 10.0% recycled binder in surface mixtures when using this originally specified PG binder.
5. Use no more than 20.0% recycled binder when using this originally specified PG binder for intermediate mixtures. Use no more than 25.0% recycled binder when using this originally specified PG binder for base mixtures.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

4.1. **Certification**. Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 6. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests. Provide AGG101 certified specialists for aggregate testing.

Table 6
Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate and Recycled Material Testing				
Sampling	Tex-221-F	✓	✓	1A/AGG101
Dry sieve	Tex-200-F, Part I	✓	✓	1A/AGG101
Washed sieve	Tex-200-F, Part II	✓	✓	1A/AGG101
Deleterious material	Tex-217-F, Parts I & III	✓	✓	AGG101
Decantation	Tex-217-F, Part II	✓	✓	AGG101
Los Angeles abrasion	Tex-410-A		✓	TxDOT
Magnesium sulfate soundness	Tex-411-A		✓	TxDOT
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Crushed face count	Tex-460-A	✓	✓	AGG101
Flat and elongated particles	Tex-280-F	✓	✓	AGG101
Linear shrinkage	Tex-107-E	✓	✓	AGG101
Sand equivalent	Tex-203-F	✓	✓	AGG101
Organic impurities	Tex-408-A	✓	✓	AGG101
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F, Part II	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F, Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Gradation & asphalt binder content[2]	Tex-236-F, Part I	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F, Part II	✓	✓	1A/AGG101
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
5. Placement Testing				
Selecting placement random numbers	Tex-225-F, Part II		✓	1B
Trimming roadway cores	Tex-251-F, Parts I & II	✓	✓	1A/1B
In-place air voids	Tex-207-F, Parts I & VI	✓	✓	1A
In-place density (nuclear method)	Tex-207-F, Part III	✓		1B
Establish rolling pattern	Tex-207-F, Part IV	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Segregation (density profile)	Tex-207-F, Part V	✓	✓	1B
Longitudinal joint density	Tex-207-F, Part VII	✓	✓	1B
Thermal profile	Tex-244-F	✓	✓	1B
Shear Bond Strength Test	Tex-249-F		✓	TxDOT

1. Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 3076.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.
3. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.

4.2. **Reporting and Responsibilities**. Use Department-provided templates to record and calculate all test data, including mixture design, production and placement QC/QA, control charts, thermal profiles, segregation density profiles, and longitudinal joint density. Obtain the current version of the templates at http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The maximum allowable time for the Contractor and Engineer to exchange test data is as given in Table 7 unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement, a payment adjustment less than 1.000, or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 7
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[2]			
Moisture content[3]			
Boil test[3]			
Production Quality Assurance			
Gradation[3]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[3]			
Laboratory-molded density[1]			
Hamburg Wheel test[4]			
Boil test[3]			
Binder tests[4]			
Placement Quality Control			
In-place air voids[2]	Contractor	Engineer	1 working day of completion of the lot
Segregation[1]			
Longitudinal joint density[1]			
Thermal profile[1]			
Placement Quality Assurance			
In-place air voids[1]	Engineer	Contractor	1 working day after receiving the trimmed cores[5]
Segregation[3]			1 working day of completion of the lot
Longitudinal joint density[3]			
Thermal profile[3]			
Aging ratio[4]			
Payment adjustment summary	Engineer	Contractor	2 working days of performing all required tests and receiving Contractor test data

1. These tests are required on every sublot.
2. Optional test. When performed on split samples, report the results as soon as they become available.
3. To be performed at the frequency specified in Table 16 or as shown on the plans.
4. To be reported as soon as the results become available.
5. 2 days are allowed if cores cannot be dried to constant weight within 1 day.

The Engineer will use the Department-provided template to calculate all payment adjustment factors for the lot. Sublot samples may be discarded after the Engineer and Contractor sign off on the payment adjustment summary documentation for the lot.

Use the procedures described in Tex-233-F to plot the results of all quality control (QC) and quality assurance (QA) testing. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. **Quality Control Plan (QCP)**. Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting. Receive approval of the QCP before beginning production. Include the following items in the QCP:

4.3.1. **Project Personnel**. For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and
- current copies of certification documents for individuals performing specified QC functions.

4.3.2. **Material Delivery and Storage**. For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

4.3.3. **Production**. For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, RAP, RAS, lime, liquid antistrip, WMA);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

4.3.4. **Loading and Transporting**. For loading and transporting, include:

- type and application method for release agents; and
- truck loading procedures to avoid segregation.

4.3.5. **Placement and Compaction**. For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver, while avoiding segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.4. **Mixture Design**.

4.4.1. **Design Requirements**. The Contractor will design the mixture using a Superpave Gyratory Compactor (SGC). A Texas Gyratory Compactor (TGC) may be used when shown on the plans. Use the dense-graded design procedure provided in Tex-204-F. Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

4.4.1.1. **Design Number of Gyrations (Ndesign) When The SGC Is Used**. Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 9. The Ndesign level may be reduced to at least 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test, and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles;
- the target laboratory-molded density (or Ndesign level when using the SGC);
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture
2"	–	–	–	–
1-1/2"	100.0[1]	–	–	–
1"	98.0–100.0	100.0[1]	–	–
3/4"	84.0–98.0	95.0–100.0	100.0[1]	–
1/2"	–	–	98.0–100.0	100.0[1]
3/8"	60.0–80.0	70.0–85.0	85.0–100.0	98.0–100.0
#4	40.0–60.0	43.0–63.0	50.0–70.0	70.0–90.0
#8	29.0–43.0	32.0–44.0	35.0–46.0	38.0–48.0
#30	13.0–28.0	14.0–28.0	15.0–29.0	12.0–27.0
#50	6.0–20.0	7.0–21.0	7.0–20.0	6.0–19.0
#200	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0
Design VMA, % Minimum				
–	13.0	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum				
–	12.5	13.5	14.5	15.5

1. Defined as maximum sieve size. No tolerance allowed.

Table 9
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, % (SGC)	Tex-207-F	96.0
Design gyrations (Ndesign for SGC)	Tex-241-F	50[1]
Indirect tensile strength (dry), psi	Tex-226-F	85–200[2]
Boil test[3]	Tex-530-C	–

1. Adjust within a range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor.
2. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
3. Used to establish baseline for comparison to production results. May be waived when approved.

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000[2]
PG 70		15,000[3]
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the Ndesign level (SGC) to at least 35 gyrations.
2. May be decreased to at least 5,000 passes when shown on the plans.
3. May be decreased to at least 10,000 passes when shown on the plans.

4.4.1.2. **Target Laboratory-Molded Density When The TGC Is Used**. Design the mixture at a 96.5% target laboratory-molded density. Increase the target laboratory-molded density to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.

4.4.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or Ndesign level), and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive. When WMA is used, document the additive or process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than 2 trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities**.

4.4.2.1.1. **Providing Gyratory Compactor**. Use a SGC calibrated in accordance with Tex-241-F to design the mixture in accordance with Tex-204-F, Part IV, for molding production samples. Locate the SGC, if used, at the Engineer's field laboratory and make the SGC available to the Engineer for use in molding production samples. Furnish a TGC calibrated in accordance with Tex-914-K when shown on the plans to design the mixture in accordance with Tex-204-F, Part I, for molding production samples.

4.4.2.1.2. **Gyratory Compactor Correlation Factors**. Use Tex-206-F, Part II, to perform a gyratory compactor correlation when the Engineer uses a different gyratory compactor. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1**. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture, and request that the Department perform the test.

4.4.2.1.4. **Supplying Aggregates**. Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.5. **Supplying Asphalt**. Provide at least 1 gal. of the asphalt material and enough quantities of any additives proposed for use.

4.4.2.1.6. **Ignition Oven Correction Factors**. Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 months old. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for QA testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used, unless otherwise directed.

4.4.2.1.7. **Boil Test**. Perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production. The Engineer may waive the requirement for the boil test.

4.4.2.1.8. **Trial Batch Production**. Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch, including the WMA additive or process if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in Table 4, Table 5, and Table 11. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment**. Use only equipment and materials proposed for use on the project to produce the trial batch.

4.4.2.1.10. **Trial Batch Quantity**. Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.11. **Number of Trial Batches**. Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.12. **Trial Batch Sampling**. Obtain a representative sample of the trial batch and split it into 3 equal portions in accordance with Tex-222-F. Label these portions as “Contractor,” “Engineer,” and “Referee.” Deliver samples to the appropriate laboratory as directed.

4.4.2.1.13. **Trial Batch Testing**. Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in Table 11. Ensure the trial batch mixture is also in compliance with the Hamburg Wheel requirement in Table 10. Use a Department-approved laboratory to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2**. Evaluate the trial batch test results after the Engineer grants full approval of JMF1 based on results from the trial batch, determine the optimum mixture proportions, and submit as JMF2. Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the voids in mineral aggregates (VMA) requirements for production shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi. Verify that JMF2 meets the mixture requirements in Table 5.

4.4.2.1.15. **Mixture Production**. Use JMF2 to produce Lot 1 as described in Section 3076.4.9.3.1.1., “Lot 1 Placement,” after receiving approval for JMF2 and a passing result from the Department’s or a Department-approved

laboratory's Hamburg Wheel test on the trial batch. If desired, proceed to Lot 1 production, once JMF2 is approved, at the Contractor's risk without receiving the results from the Department's Hamburg Wheel test on the trial batch.

Notify the Engineer if electing to proceed without Hamburg Wheel test results from the trial batch. Note that the Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

4.4.2.1.16. **Development of JMF3**. Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.17. **JMF Adjustments**. If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of JMF2 listed in Table 11.

4.4.2.1.18. **Requesting Referee Testing**. Use referee testing, if needed, in accordance with Section 3076.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 11
Operational Tolerances

Description	Test Method	Allowable Difference Between Trial Batch and JMF1 Target	Allowable Difference from Current JMF Target	Allowable Difference between Contractor and Engineer[1]
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be Within Master Grading Limits in Table 8	±5.0[2,3]	±5.0
Individual % retained for sieves smaller than #8 and larger than #200			±3.0[2,3]	±3.0
% passing the #200 sieve			±2.0[2,3]	±1.6
Asphalt binder content, %	Tex-236-F	±0.5	±0.3[3]	±0.3
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±1.0
In-place air voids, %		N/A	N/A	±1.0
Laboratory-molded bulk specific gravity		N/A	N/A	±0.020
VMA, %, min	Tex-204-F	Note[4]	Note[4]	N/A
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	N/A	±0.020

1. Contractor may request referee testing only when values exceed these tolerances.
2. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
3. Only applies to mixture produced for Lot 1 and higher.
4. Test and verify that Table 8 requirements are met.

4.4.2.2. **Engineer's Responsibilities**.

4.4.2.2.1. **Gyratory Compactor**. For SGC mixtures designed in accordance with Tex-204-F, Part IV, the Engineer will use a Department SGC, calibrated in accordance with Tex-241-F, to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location. The Engineer will make the Contractor-provided SGC in the Department field laboratory available to the Contractor for molding verification samples.

For TGC mixtures designed in accordance with Tex-204-F, Part I, the Engineer will use a Department TGC, calibrated in accordance with Tex-914-K, to mold samples for trial batch and production testing. The Engineer will make the Department TGC and the Department field laboratory available to the Contractor for molding verification samples, if requested by the Contractor.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch**. The Engineer will review and verify conformance of the following information within 2 working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results;
- all required materials including aggregates, asphalt, additives, and recycled materials; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 3076.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after two working days, conditional approval of JMF1 will still be granted within two working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

After conditionally approving JMF1, including either Contractor- or Department-supplied Hamburg Wheel test results, the Contractor is authorized to produce a trial batch.

4.4.2.2.3. **Hamburg Wheel Testing of JMF1**. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the laboratory mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

4.4.2.2.4. **Ignition Oven Correction Factors**. The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for QA testing during production in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 months old.

4.4.2.2.5. **Testing the Trial Batch**. Within 1 full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements in Table 11. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

The Engineer will have the option to perform the following tests on the trial batch:

- Tex-226-F, to verify that the indirect tensile strength meets the requirement shown in Table 9; and
- Tex-530-C, to retain and use for comparison purposes during production.

4.4.2.2.6. **Full Approval of JMF1**. The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in Table 11. The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. **Approval of JMF2**. The Engineer will approve JMF2 within one working day if the mixture meets the requirements in Table 5 and the gradation meets the master grading limits shown in Table 8. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi.

4.4.2.2.8. **Approval of Lot 1 Production**. The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2) as soon as a passing result is achieved from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. The Contractor may proceed at its own risk with Lot 1 production without the results from the Hamburg Wheel test on the trial batch.

If the Department's or Department-approved laboratory's sample from the trial batch fails the Hamburg Wheel test, the Engineer will suspend production until further Hamburg Wheel tests meet the specified values. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test be removed and replaced at the Contractor's expense.

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes**. JMF3 and subsequent JMF changes are approved if they meet the mixture requirements shown in Table 4, Table 5, and the master grading limits shown in Table 8, and are within the operational tolerances of JMF2 shown in Table 11.

4.5. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

4.5.1. **Storage and Heating of Materials**. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. **Mixing and Discharge of Materials**. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed the maximum production temperatures listed in Table 12 (or 275°F for WMA). The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures listed in Table 12.

Table 12
Maximum Production Temperature

High-Temperature Binder Grade[1]	Maximum Production Temperature
PG 64	325˚F
PG 70	335˚F
PG 76	345˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.

Produce WMA within the target discharge temperature range of 215°F and 275°F when WMA is required. Take corrective action any time the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor's corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with

Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck, and perform the test promptly.

4.6. **Hauling Operations**. Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department's MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 3076.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. **Placement Operations**. Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines and are not placed in the wheel path, or as directed. Ensure that all finished surfaces will drain properly. Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 13 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 13
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Minimum Untrimmed Core Height (in.) Eligible for Testing
	Minimum (in.)	Maximum (in.)	
B	2.50	5.00	1.75
C	2.00	4.00	1.50
D	1.50	3.00	1.25
F	1.25	2.50	1.25

4.7.1. **Weather Conditions**.

4.7.1.1. **When Using a Thermal Imaging System**. Place mixture when the roadway surface is dry and the roadway surface temperature is at or above the temperatures listed in Table 14A. The Engineer may restrict the Contractor from paving surface mixtures if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 3076.4.7.3.1.2., "Thermal Imaging System."

Table 14A
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64	35	40
PG 70	45[2]	50[2]
PG 76	45[2]	50[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture or when using WMA.

4.7.1.2. **When Not Using a Thermal Imaging System**. When using a thermal camera instead of the thermal imaging system, place mixture when the roadway surface temperature is at or above the temperatures listed in Table 14B unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving.

Table 14B
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64	45	50
PG 70	55[2]	60[2]
PG 76	60[2]	60[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture, when using WMA, or utilizing a paving process with equipment that eliminates thermal segregation. In such cases, for each sublot and in the presence of the Engineer, use a hand-held thermal camera operated in accordance with Tex-244-F to demonstrate to the satisfaction of the Engineer that the uncompacted mat has no more than 10°F of thermal segregation.

4.7.2. **Tack Coat**.

4.7.2.1. **Application.** Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply the tack coat to all surfaces that will come in contact with the subsequent HMA placement, unless otherwise directed. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

4.7.2.2. **Sampling.** The Engineer will obtain at least one sample of the tack coat binder per project in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300, “Asphalts, Oils, and Emulsions.” The Engineer will notify the Contractor when the sampling will occur and will witness the collection of the sample from the asphalt distributor immediately before use.

For emulsions, the Engineer may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in Item 300, “Asphalts, Oils, and Emulsions.”

4.7.3. **Lay-Down Operations**. Use the placement temperatures in Table 15 to establish the minimum placement temperature of the mixture delivered to the paver.

Table 15
Minimum Mixture Placement Temperature

High-Temperature Binder Grade[1]	Minimum Placement Temperature (Before Entering Paver)[2,3]
PG 64	260˚F
PG 70	270˚F
PG 76	280˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Minimum placement temperatures may be reduced 10°F if using a chemical WMA additive as a compaction aid.
3. When using WMA, the minimum placement temperature is 215°F.

4.7.3.1. **Thermal Profile**. Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F. Thermal profiles are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas."

4.7.3.1.1. **Thermal Segregation**.

4.7.3.1.1.1. **Moderate**. Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F, are deemed as moderate thermal segregation.

4.7.3.1.1.2. **Severe**. Any areas that have a temperature differential greater than 50°F are deemed as severe thermal segregation.

4.7.3.1.2. **Thermal Imaging System**. Review the output results when a thermal imaging system is used, and provide the automated report described in Tex-244-F to the Engineer daily unless otherwise directed. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system. The Engineer may suspend paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe thermal segregation. Density profiles are not required and not applicable when using a thermal imaging system. Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots daily or upon completion of the project or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera**. When using a thermal camera instead of the thermal imaging system, take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Evaluate areas with moderate thermal segregation by performing density profiles in accordance with Section 3076.4.9.3.3.2., "Segregation (Density Profile)." Provide the Engineer with the thermal profile of every sublot within one working day of the completion of each lot. When requested by the Engineer, provide the thermal images generated using the thermal camera. Report the results of each thermal profile in accordance with Section 3076.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains severe thermal segregation. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section. Evaluate areas with severe thermal segregation by performing density profiles in accordance with Section 3076.4.9.3.3.2., "Segregation (Density Profile)." Remove and replace the material in any areas that have both severe thermal segregation and a failing result for Segregation (Density Profile) unless otherwise directed. The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

4.7.3.2. **Windrow Operations**. Operate windrow pickup equipment so that when hot-mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.7.3.3. **Hauling Equipment**. Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability or when a thermal imaging system is used unless otherwise allowed.

4.7.3.4. **Screed Heaters**. Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 3076.4.9.3.3.4., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. **Compaction**. Compact the pavement uniformly to contain between 3.8% and 8.5% in-place air voids. Take immediate corrective action to bring the operation within 3.8% and 8.5% when the in-place air voids exceed the range of these tolerances. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.8% and 8.5% in-place air voids.

Obtain cores in areas placed under Exempt Production, as directed, at locations determined by the Engineer. The Engineer may test these cores and suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or more than 9.9%. Areas defined in Section 3076.4.9.3.1.4., "Miscellaneous Areas," are not subject to in-place air void determination.

Furnish the type, size, and number of rollers required for compaction as approved. Use additional rollers as required to remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. **Acceptance Plan**. Payment adjustments for the material will be in accordance with Article 3076.6., "Payment."

Sample and test the hot-mix on a lot and sublot basis. Suspend production until test results or other information indicates to the satisfaction of the Engineer that the next material produced or placed will result in payment factors of at least 1.000, if the production payment factor given in Section 3076.6.1., "Production Payment Adjustment Factors," for two consecutive lots or the placement pay factor given in Section 3076.6.2., "Placement Payment Adjustment Factors," for two consecutive lots is below 1.000.

4.9.1. **Referee Testing**. The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if a "remove and replace" condition is determined based on the Engineer's test results, or if the differences between Contractor and Engineer test results exceed the maximum allowable difference shown in Table 11 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within five working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the sublot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to

be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than three referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

The Materials and Tests Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample. The in-place air voids will be determined based on the bulk specific gravity of the cores, as determined by the referee laboratory and the Engineer's average maximum theoretical specific gravity for the lot. With the exception of "remove and replace" conditions, referee test results are final and will establish payment adjustment factors for the sublot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement payment adjustment factor for any sublot results in a "remove and replace" condition. Placement sublots subject to be removed and replaced will be further evaluated in accordance with Section 3076.6.2.2., "Placement Sublots Subject to Removal and Replacement."

4.9.2. **Production Acceptance**.

4.9.2.1. **Production Lot**. A production lot consists of four equal sublots. The default quantity for Lot 1 is 1,000 tons; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 4,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately three to four sublots are produced each day. The lot size will be between 1,000 tons and 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot.

If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 to confirm the indirect tensile strength does not exceed 200 psi. Take corrective action to bring the mixture within specification compliance if the indirect tensile strength exceeds 200 psi unless otherwise directed.

4.9.2.1.1. **Incomplete Production Lots**. If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Adjust the payment for the incomplete lot in accordance with Section 3076.6.1., "Production Payment Adjustment Factors." Close all lots within five working days unless otherwise allowed.

4.9.2.2. **Production Sampling**.

4.9.2.2.1. **Mixture Sampling**. Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into three equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample**. At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample**. For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.2.2.2. **Informational Shear Bond Strength Testing.** Select one random sublot from Lot 2 or higher for shear bond strength testing. Obtain full depth cores in accordance with Tex-249-F. Label the cores with the Control Section Job (CSJ), producer of the tack coat, mix type, shot rate, lot, and sublot number and provide to the

Engineer. The Engineer will ship the cores to the Materials and Tests Division or district laboratory for shear bond strength testing. Results from these tests will not be used for specification compliance.

4.9.2.2.3. **Asphalt Binder Sampling**. Obtain a 1-qt. sample of the asphalt binder witnessed by the Engineer for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill and upstream from the introduction of any additives in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers, producer, producer facility location, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain these samples for one year. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor.

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to MTD to verify compliance with Item 300, “Asphalts, Oils, and Emulsions” and will retain the other split sample for one year.

4.9.2.3. **Production Testing**. The Contractor and Engineer must perform production tests in accordance with Table 16. The Contractor has the option to verify the Engineer’s test results on split samples provided by the Engineer. Determine compliance with operational tolerances listed in Table 11 for all sublots.

Take immediate corrective action if the Engineer’s laboratory-molded density on any sublot is less than 95.0% or greater than 97.0% to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor’s corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F, Part I does not yield reliable results. Provide evidence that results from Tex-236-F, Part I are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 16
Production and Placement Testing Frequency

Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	1 per sublot	1 per 12 sublots[1]
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	N/A	1 per sublot[1]
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	Tex-204-F		
Segregation (density profile)[2]	Tex-207-F, Part V	1 per sublot	1 per project
Longitudinal joint density	Tex-207-F, Part VII		
Moisture content	Tex-212-F, Part II	When directed	
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	1 per sublot[1]
Asphalt binder content	Tex-236-F	1 per sublot	1 per lot[1]
Hamburg Wheel test	Tex-242-F	N/A	1 per project
Recycled Asphalt Shingles (RAS)[3]	Tex-217-F, Part III	N/A	
Thermal profile[2]	Tex-244-F	1 per sublot	
Asphalt binder sampling and testing	Tex-500-C, Part II	1 per lot (sample only)[4]	
Tack coat sampling and testing	Tex-500-C, Part III	N/A	
Boil test[5]	Tex-530-C	1 per lot	
Shear Bond Strength Test[6]	Tex-249-F	1 per project (sample only)	

1. For production defined in Section 3076.4.9.4., "Exempt Production," the Engineer will test one per day if 100 tons or more are produced. For Exempt Production, no testing is required when less than 100 tons are produced.
2. Not required when a thermal imaging system is used.
3. Testing performed by the Materials and Tests Division or designated laboratory.
4. Obtain witnessed by the Engineer. The Engineer will retain these samples for one year.
5. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.
6. Testing performed by the Materials and Tests Division or District for informational purposes only.

4.9.2.4. **Operational Tolerances**. Control the production process within the operational tolerances listed in Table 11. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.2.4.1. **Gradation**. Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size shown in Table 8. A sublot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances in Table 11 for three consecutive sublots on the same sieve or four consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

4.9.2.4.2. **Asphalt Binder Content**. A sublot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values listed in Table 11. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that is out of operational tolerance for asphalt binder content. Suspend production and shipment of the mixture if the Engineer's or the Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any sublot.

4.9.2.4.3. **Voids in Mineral Aggregates (VMA)**. The Engineer will determine the VMA for every sublot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any sublot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA results on two consecutive sublots are below the minimum VMA requirement for production listed in Table 8. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that does not

meet the minimum VMA requirement for production listed in Table 8 based on the Engineer's VMA determination.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment.

4.9.2.4.4. **Hamburg Wheel Test**. The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 10. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Materials and Tests Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

4.9.2.5. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.3. **Placement Acceptance**.

4.9.3.1. **Placement Lot**. A placement lot consists of four placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.3.1.1. **Lot 1 Placement**. Placement payment adjustments greater than 1.000 for Lot 1 will be in accordance with Section 3076.6.2., "Placement Payment Adjustment Factors"; however, no placement adjustment less than 1.000 will be assessed for any sublot placed in Lot 1 when the in-place air voids are greater than or equal to 2.7% and less than or equal to 9.9%. Remove and replace any sublot with in-place air voids less than 2.7% or greater than 9.9%.

4.9.3.1.2. **Incomplete Placement Lots**. An incomplete placement lot consists of the area placed as described in Section 3076.4.9.2.1.1., "Incomplete Production Lots," excluding areas defined in Section 3076.4.9.3.1.4., "Miscellaneous Areas." Placement sampling is required if the random sample plan for production resulted in a sample being obtained from an incomplete production sublot.

4.9.3.1.3. **Shoulders, Ramps, Etc**. Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are subject to in-place air void determination and payment adjustments unless designated on the plans as not eligible for in-place air void determination. Intersections may be considered miscellaneous areas when determined by the Engineer.

4.9.3.1.4. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Temporary detours are subject to in-place air void determination when shown on the plans. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 13. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of

pavement unless another rate is shown on the plans. When "level up" is listed as part of the item bid description code, a payment adjustment factor of 1.000 will be assigned for all placement sublots as described in Article 3076.6, "Payment." Miscellaneous areas are not eligible for random placement sampling locations. Compact miscellaneous areas in accordance with Section 3076.4.8., "Compaction." Miscellaneous areas are not subject to in-place air void determination, thermal profiles testing, segregation (density profiles), or longitudinal joint density evaluations.

4.9.3.2. **Placement Sampling**. The Engineer will select random numbers for all placement sublots at the beginning of the project. The Engineer will provide the Contractor with the placement random numbers immediately after the sublot is completed. Mark the roadway location at the completion of each sublot and record the station number. Determine one random sample location for each placement sublot in accordance with Tex-225-F. Adjust the random sample location by no more than necessary to achieve a 2-ft. clearance if the location is within 2 ft. of a joint or pavement edge.

Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are always eligible for selection as a random sample location; however, if a random sample location falls on one of these areas and the area is designated on the plans as not subject to in-place air void determination, cores will not be taken for the sublot and a 1.000 pay factor will be assigned to that sublot.

Provide the equipment and means to obtain and trim roadway cores on site. On-site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement sublot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side from within 1 ft. of the random location provided for the placement sublot. For Type D and Type F mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness. Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with Tex-251-F if the core heights meet the minimum untrimmed value listed in Table 13. Trim the cores on site in the presence of the Engineer. Use a permanent marker or paint pen to record the lot and sublot numbers on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after witnessing the trimming of the cores and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at http://www.txdot.gov/business/specifications.htm to provide a secure means and process that protects the integrity of the cores during transport.

Decide whether to include the pair of cores in the air void determination for that sublot if the core height before trimming is less than the minimum untrimmed value shown in Table 13. Trim the cores as described above before delivering to the Engineer if electing to have the cores included in the air void determination. Deliver untrimmed cores to the Engineer and inform the Engineer of the decision to not have the cores included in air void determination if electing to not have the cores included in air void determination. The placement pay factor for the sublot will be 1.000 if cores will not be included in air void determination.

Instead of the Contractor trimming the cores on site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores

immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

4.9.3.3. **Placement Testing**. Perform placement tests in accordance with Table 16. After the Engineer returns the cores, the Contractor may test the cores to verify the Engineer's test results for in-place air voids. The allowable differences between the Contractor's and Engineer's test results are listed in Table 11.

4.9.3.3.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores may be pre-dried using a CoreDry or similar vacuum device to remove excess moisture. The Engineer will average the values obtained for all sublots in the production lot to determine the theoretical maximum specific gravity. The Engineer will use the average air void content for in-place air voids.

The Engineer will use the vacuum method to seal the core if required by Tex-207-F. The Engineer will use the test results from the unsealed core to determine the placement payment adjustment factor if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

4.9.3.3.2. **Segregation (Density Profile)**. Test for segregation using density profiles in accordance with Tex-207-F, Part V when using a thermal camera insead of the thermal imaging system. Density profiles are not required and are not applicable when using a thermal imaging system. Density profiles are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas."

Perform a minimum of one density profile per sublot. Perform additional density profiles when any of the following conditions occur, unless otherwise approved:

- the paver stops due to lack of material being delivered to the paving operations and the temperature of the uncompacted mat before the initial break down rolling is less than the temperatures shown in Table 17;
- areas that are identified by either the Contractor or the Engineer with thermal segregation;,
- any visibly segregated areas that exist.

Table 17
Mimimum Uncompacted Mat Temperature Requiring a Segregation Profile

High-Temperature Binder Grade[1]	Minimum Temperature of the Uncompacted Mat Allowed Before Initial Break Down Rolling[2,3,4]
PG 64	<250˚F
PG 70	<260˚F
PG 76	<270˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Segregation profiles are required in areas with moderate and severe thermal segregation as described in Section 3076.4.7.3.1.3.
3. Minimum uncompacted mat temperature requiring a segregation profile may be reduced 10°F if using a chemical WMA additive as a compaction aid.
4. When using WMA, the minimum uncompacted mat temperature requiring a segregation profile is 215°F.

Provide the Engineer with the density profile of every sublot in the lot within one working day of the completion of each lot. Report the results of each density profile in accordance with Section 3076.4.2., "Reporting and Responsibilities."

The density profile is considered failing if it exceeds the tolerances in Table 18. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains a failing density profile. When a hand-held thermal camera is used instead of a thermal imaging system, the Engineer will measure the density profile at least once per project. The Engineer's density profile results will be used when available. The Engineer may require the Contractor to remove and replace the area in question if the area fails the density profile and has surface irregularities as defined in Section 3076.4.9.3.3.5., "Irregularities." The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

Investigate density profile failures and take corrective actions during production and placement to eliminate the segregation. Suspend production if 2 consecutive density profiles fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Table 18
Segregation (Density Profile) Acceptance Criteria

Mixture Type	Maximum Allowable Density Range (Highest to Lowest)	Maximum Allowable Density Range (Average to Lowest)
Type B	8.0 pcf	5.0 pcf
Type C, Type D & Type F	6.0 pcf	3.0 pcf

4.9.3.3.3. **Longitudinal Joint Density**.

4.9.3.3.3.1. **Informational Tests**. Perform joint density evaluations while establishing the rolling pattern and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern, if needed, to achieve the desired joint density. Perform additional joint density evaluations, at least once per sublot, unless otherwise directed.

4.9.3.3.3.2. **Record Tests**. Perform a joint density evaluation for each sublot at each pavement edge that is or will become a longitudinal joint. Joint density evaluations are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas." Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results on Department forms to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer will make independent joint density verification at least once per project and may make independent joint density verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Provide the Engineer with the joint density of every sublot in the lot within one working day of the completion of each lot. Report the results of each joint density in accordance with Section 3076.4.2., "Reporting and Responsibilities."

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if the evaluations on two consecutive sublots fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

4.9.3.3.4. **Recovered Asphalt Dynamic Shear Rheometer (DSR)**. The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Materials and Tests Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with Tex-211-F.

4.9.3.3.5. **Irregularities**. Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) areas where the mixture does not bond to the existing pavement.

If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.4. **Exempt Production**. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is less than 500 tons;
- total production for the project is less than 5,000 tons;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements, except for coring operations when required by the Engineer. The production and placement pay factors are 1.000 if the specification requirements listed below are met, all other specification requirements are met, and the Engineer performs acceptance tests for production and placement listed in Table 16 when 100 tons or more per day are produced.

- produce, haul, place, and compact the mixture in compliance with the specification and as directed;
- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target laboratory-molded density as tested by the Engineer;
- compact the mixture in accordance with Section 3076.4.8., "Compaction;" and
- when a thermal imaging system is not used, the Engineer may perform segregation (density profiles) and thermal profiles in accordance with the specification.

4.9.5. **Ride Quality**. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

5.1. **Dense Graded Hot-Mix Asphalt.** Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.2. **Tack Coat.** Tack coat will be measured at the applied temperature by strapping the tank before and after road application and determining the net volume in gallons from the calibrated distributor. The Engineer will witness all strapping operations for volume determination. All tack, including emulsions, will be measured by the gallon applied.

The Engineer may allow the use of a metering device to determine asphalt volume used and application rate if the device is accurate within 1.5% of the strapped volume.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3076.5.1, "Measurement," will be paid for at the unit bid price for "Dense Graded Hot-Mix Asphalt" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Article 3076.5.2, "Measurement," will be paid for at the unit bid price for "Tack Coat" of the tack coat provided. These prices are full compensation for materials, placement, equipment, labor, tools, and incidentals. Payment adjustments will be applied as determined in this Item; however, a payment adjustment factor of 1.000 will be assigned for all placement sublots for "level ups" only when "level up" is listed as part of the item bid description code. A payment adjustment factor of 1.000 will be assigned to all production and placement sublots when "exempt" is listed as part of the item bid description code, and all testing requirements are met.

Payment for each sublot, including applicable payment adjustments greater than 1.000, will only be paid for sublots when the Contractor supplies the Engineer with the required documentation for production and placement QC/QA, thermal profiles, segregation density profiles, and longitudinal joint densities in accordance with Section 3076.4.2., "Reporting and Responsibilities." When a thermal imaging system is used, documentation is not required for thermal profiles or segregation density profiles on individual sublots; however, the thermal imaging system automated reports described in Tex-244-F are required.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

6.1. **Production Payment Adjustment Factors**. The production payment adjustment factor is based on the laboratory-molded density using the Engineer's test results. The bulk specific gravities of the samples from each sublot will be divided by the Engineer's maximum theoretical specific gravity for the sublot. The individual sample densities for the sublot will be averaged to determine the production payment adjustment factor in accordance with Table 19 for each sublot, using the deviation from the target laboratory-molded density defined in Table 9. The production payment adjustment factor for completed lots will be the average of the payment adjustment factors for the four sublots sampled within that lot.

Table 19
Production Payment Adjustment Factors for Laboratory-Molded Density[1]

Absolute Deviation from Target Laboratory-Molded Density	Production Payment Adjustment Factor (Target Laboratory-Molded Density)
0.0	1.050
0.1	1.050
0.2	1.050
0.3	1.044
0.4	1.038
0.5	1.031
0.6	1.025
0.7	1.019
0.8	1.013
0.9	1.006
1.0	1.000
1.1	0.965
1.2	0.930
1.3	0.895
1.4	0.860
1.5	0.825
1.6	0.790
1.7	0.755
1.8	0.720
> 1.8	Remove and replace

1. If the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 98.0%, take immediate corrective action to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

6.1.1. **Payment for Incomplete Production Lots**. Production payment adjustments for incomplete lots, described under Section 3076.4.9.2.1.1., "Incomplete Production Lots," will be calculated using the average production payment factors from all sublots sampled.

A production payment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples within the first sublot.

6.1.2. **Production Sublots Subject to Removal and Replacement**. If after referee testing, the laboratory-molded density for any sublot results in a "remove and replace" condition as listed in Table 19, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 3076.5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.2. **Placement Payment Adjustment Factors**. The placement payment adjustment factor is based on in-place air voids using the Engineer's test results. The bulk specific gravities of the cores from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the placement payment adjustment factor in accordance with Table 20 for each sublot that requires in-place air void measurement. A placement payment adjustment factor of 1.000 will be assigned to the entire sublot when the random sample location falls in an area designated on the plans as not subject to in-place air void determination. A placement payment adjustment factor of 1.000 will be assigned to quantities placed in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas." The placement payment adjustment factor for completed lots will be the average of the placement payment adjustment factors for up to four sublots within that lot.

Table 20
Placement Payment Adjustment Factors for In-Place Air Voids

In-Place Air Voids	Placement Pay Adjustment Factor	In-Place Air Voids	Placement Pay Adjustment Factor
< 2.7	Remove and Replace	6.4	1.042
2.7	0.710	6.5	1.040
2.8	0.740	6.6	1.038
2.9	0.770	6.7	1.036
3.0	0.800	6.8	1.034
3.1	0.830	6.9	1.032
3.2	0.860	7.0	1.030
3.3	0.890	7.1	1.028
3.4	0.920	7.2	1.026
3.5	0.950	7.3	1.024
3.6	0.980	7.4	1.022
3.7	0.998	7.5	1.020
3.8	1.002	7.6	1.018
3.9	1.006	7.7	1.016
4.0	1.010	7.8	1.014
4.1	1.014	7.9	1.012
4.2	1.018	8.0	1.010
4.3	1.022	8.1	1.008
4.4	1.026	8.2	1.006
4.5	1.030	8.3	1.004
4.6	1.034	8.4	1.002
4.7	1.038	8.5	1.000
4.8	1.042	8.6	0.998
4.9	1.046	8.7	0.996
5.0	1.050	8.8	0.994
5.1	1.050	8.9	0.992
5.2	1.050	9.0	0.990
5.3	1.050	9.1	0.960
5.4	1.050	9.2	0.930
5.5	1.050	9.3	0.900
5.6	1.050	9.4	0.870
5.7	1.050	9.5	0.840
5.8	1.050	9.6	0.810
5.9	1.050	9.7	0.780
6.0	1.050	9.8	0.750
6.1	1.048	9.9	0.720
6.2	1.046	> 9.9	Remove and Replace
6.3	1.044		

6.2.1. **Payment for Incomplete Placement Lots**. Payment adjustments for incomplete placement lots described under Section 3076.4.9.3.1.2., "Incomplete Placement Lots," will be calculated using the average of the placement payment factors from all sublots sampled and sublots where the random location falls in an area designated on the plans as not eligible for in-place air void determination.

If the random sampling plan results in production samples, but not in placement samples, the random core location and placement adjustment factor for the sublot will be determined by applying the placement random number to the length of the sublot placed.

If the random sampling plan results in placement samples, but not in production samples, no placement adjustment factor will apply for that sublot placed.

A placement payment adjustment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any production samples.

6.2.2. **Placement Sublots Subject to Removal and Replacement**. If after referee testing, the placement payment adjustment factor for any sublot results in a "remove and replace" condition as listed in Table 20, the Engineer will choose the location of two cores to be taken within 3 ft. of the original failing core location. The Contractor will obtain the cores in the presence of the Engineer. The Engineer will take immediate possession of the untrimmed cores and submit the untrimmed cores to the Materials and Tests Division, where they will be trimmed if necessary and tested for bulk specific gravity within 10 working days of receipt.

The bulk specific gravity of the cores from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the new payment adjustment factor of the sublot in question. If the new payment adjustment factor is 0.700 or greater, the new payment adjustment factor will apply to that sublot. If the new payment adjustment factor is less than 0.700, no payment will be made for the sublot. Remove and replace the failing sublot, or the Engineer may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 3076.5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.3. **Total Adjusted Pay Calculation**. Total adjusted pay (TAP) will be based on the applicable payment adjustment factors for production and placement for each lot.

$TAP = (A+B)/2$

where:
A = Bid price × production lot quantity × average payment adjustment factor for the production lot
B = Bid price × placement lot quantity × average payment adjustment factor for the placement lot + (bid price × quantity placed in miscellaneous areas × 1.000)

Production lot quantity = Quantity actually placed - quantity left in place without payment

Placement lot quantity = Quantity actually placed - quantity left in place without payment - quantity placed in miscellaneous areas

Special Specification 3079
Permeable Friction Course

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) surface course composed of a compacted permeable mixture of aggregate, asphalt binder, and additives mixed hot in a mixing plant.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate.** Furnish aggregates from sources that conform to the requirements in accordance with Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse aggregate. Do not use intermediate or fine aggregate in permeable friction course (PFC) mixtures. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests in accordance with Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. **Coarse Aggregate.** Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance;
- approved only when tested by the Engineer;
- once approved, do not add material to the stockpile unless otherwise approved; and
- allow 30 calendar days for the Engineer to sample, test, and report results.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes, unless otherwise shown on the plans. SAC requirements apply to aggregates used on surfaces other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates.** To prevent crushing of the Class B aggregate when blending, Class B aggregate may be blended with a Class A aggregate to meet requirements for Class A materials if the Department's BRSQC rated source soundness magnesium (RSSM) rating for the Class B aggregate is less than the Class A aggregate or if the RSSM rating for the Class B aggregate is less than or equal to 10%. Use the rated values for hot mix asphaltic concrete (HMAC) published in the BRSQC. When blending Class A and B aggregates to meet a Class A requirement, ensure that at least 50% by weight, or volume if required, of all the aggregates used in the mixture design retained on the No. 4 sieve comes from the Class A aggregate source, unless otherwise shown on the plans. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Class B aggregate may be disallowed when shown on the plans.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.1.2. **Micro-Deval Abrasion.** The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 10 as listed in the BRSQC, unless otherwise directed. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
RSSM = Rated Source Soundness Magnesium
$MD_{act.}$ = actual Micro-Deval percent loss
RSMD = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Soils and Aggregates Section of the Materials and Tests Division, and additional testing may be required before granting approval.

Table 1
Coarse Aggregate Quality Requirements

Property	Test Method	Requirement
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.0
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note [1]
Los Angeles abrasion, %, Max	Tex-410-A	30
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	20
Crushed face count,[2] %, Min	Tex-460-A, Part I	95
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 3079.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.

2.2. **Baghouse Fines.** Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.3. **Asphalt Binder.** Furnish the type and grade of binder specified on the plans that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions."

2.3.1. **Performance-Graded (PG) Binder.** Provide an asphalt binder with a high-temperature grade of PG 76 and low-temperature grade as shown on the plans in accordance with Section 300.2.10., "Performance-Graded Binders," when PG binder is specified.

2.3.2. **Asphalt-Rubber (A-R) Binder.** Provide A-R binder that meets the Type I or Type II requirements of Section 300.2.9., "Asphalt-Rubber Binders," when A-R is specified unless otherwise shown on the plans. Use at least 15.0% by weight of Crumb Rubber Modifier (CRM) that meets the Grade B or Grade C requirements of Section 300.2.7., "Crumb Rubber Modifier," unless otherwise shown on the plans. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal. Provide the Engineer with documentation such as the bill of lading showing the quantity of CRM used in the project unless otherwise directed.

2.4. **Tack Coat.** Furnish CSS-1H, SS-1H, EBL, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized tack coat materials listed on the Department's Tracking Resistant Asphalt Interlayer (TRAIL) MPL may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

2.5. **Additives.** Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

2.5.1. **Fibers.** Provide cellulose or mineral fibers when PG binder is specified. Do not use fibers when A-R binder is specified. Submit written certification to the Engineer that the fibers proposed for use meet the requirements of DMS-9204, "Fiber Additives for Bituminous Mixtures." Fibers may be pre-blended into the binder at the asphalt supply terminal unless otherwise shown on the plans.

2.5.2. **Lime Mineral Filler.** Add lime as mineral filler at a rate of 1.0% by weight of the total dry aggregate in accordance with Item 301, "Asphalt Antistripping Agents," unless otherwise shown on the plans or waived by the Engineer based on Hamburg Wheel test results. Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.5.3. **Lime and Liquid Antistripping Agent.** When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum. When the plans require lime to be added as an antistripping agent, lime added as mineral filler will count towards the total quantity of lime specified.

2.5.4. **Compaction Aid.** Compaction aid is defined as a Department-approved chemical warm mix additive denoted as "chemical additive" on the Department's materials producer list (MPL) that is used to facilitate mixing and compaction of HMA.

Compaction aid is allowed for use on all projects. Compaction aid is required when shown on the plans or as required in Section 3079.4.7.1., "Weather Conditions."

Warm mix foaming processes, denoted as "foaming process" on the Department-approved MPL, may be used to facilitate mixing and compaction of HMA; however warm mix foaming processes are not defined as a Compaction aid.

2.6. **Recycled Materials.** Recycled materials are not allowed for use.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, “Equipment for Asphalt Concrete Pavement.” When A-R binder is specified, equip the hot-mix plant with an in-line viscosity-measuring device located between the blending unit and the mixing drum. Provide a means to calibrate the asphalt mass flow meter on-site when a meter is used.

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, “Control of the Work.” Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

4.1. **Certification.** Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 2. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests. Provide Level AGG101 certified specialists for aggregate testing.

Table 2
Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate Testing				
Sampling	Tex-221-F	✓	✓	1A/AGG101
Dry sieve	Tex-200-F, Part I	✓	✓	1A/AGG101
Washed sieve	Tex-200-F, Part II	✓	✓	1A/AGG101
Deleterious material	Tex-217-F, Parts I & III	✓	✓	AGG101
Decantation	Tex-217-F, Part II	✓	✓	AGG101
Los Angeles abrasion	Tex-410-A		✓	Department
Magnesium sulfate soundness	Tex-411-A		✓	Department
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Crushed face count	Tex-460-A	✓	✓	AGG101
Flat and elongated particles	Tex-280-F	✓	✓	AGG101
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I, VI, & VIII	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F, Part II	✓	✓	2
Drain-down	Tex-235-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Boil test[4]	Tex-530-C	✓	✓	1A
Cantabro loss	Tex-245-F	✓	✓	1A
4. Production Testing				
Control charts	Tex-233-F	✓	✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Gradation & asphalt binder content[2]	Tex-236-F, Part I	✓	✓	1A
Moisture content	Tex-212-F, Part II	✓	✓	1A/AGG101
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Drain-down	Tex-235-F	✓	✓	1A
Boil test[4]	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	Department
5. Placement Testing				
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Thermal profile	Tex-244-F	✓	✓	1B
Water flow test	Tex-246-F	✓	✓	1B
Shear bond strength test	Tex-249-F		✓	Department

1. Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 3079.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.
3. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.
4. When shown on the plans.

4.2. **Reporting and Responsibilities**. Use Department-provided templates to record and calculate all test data, including mixture design, production and placement tests, control charts, and thermal profiles. Obtain the current version of the templates at https://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The maximum allowable time for the Contractor and Engineer to exchange test data is given in Table 3. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 3
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[1]			
Moisture content[2]			
Drain-down[1]			
Boil test[4]			
Production Quality Assurance			
Gradation[2]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[2]			
Laboratory-molded density[2]			
Hamburg Wheel test[3]			
Boil test[4]			
Drain-down[2]			
Binder tests[3]			
Placement Quality Control			
Thermal profile[1]	Contractor	Engineer	1 working day of completion of the lot
Water flow[1]			
Placement Quality Assurance			
Thermal profile[2]	Engineer	Contractor	1 working day of completion of the lot
Aging ratio[3]			
Water flow[2]			

1. These tests are required on every sublot.
2. To be performed at the frequency in accordance with Table 9 or as shown on the plans.
3. To be reported as soon as the results become available.
4. When shown on the plans

Use the procedures described in Tex-233-F to plot the results of all production and placement testing, when directed. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. **Quality Control Plan (QCP).** Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting when directed. Receive approval of the QCP before pre-paving meeting. Include the following items in the QCP:

4.3.1. **Project Personnel.** For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and

- current copies of certification documents for individuals performing specified QC functions.

4.3.2. **Material Delivery and Storage.** For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

4.3.3. **Production.** For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, lime, liquid antistrip, compaction aid, foaming process, fibers);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

4.3.4. **Loading and Transporting.** For loading and transporting, include:

- type and application method for release agents; and
- truck loading procedures to avoid segregation.

4.3.5. **Placement and Compaction.** For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., production rate, paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver, while avoiding physical and thermal segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., speed, operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.4. **Mixture Design.**

4.4.1. **Design Requirements.** Use the PFC design procedure provided in Tex-204-F, unless otherwise shown on the plans. Design the mixture to meet the requirements in accordance with Tables 1, 4, 5, and 6. Use a Superpave Gyratory Compactor (SGC) at 50 gyrations as the design number of gyrations (Ndesign).

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;

- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 4
Master Gradation Limits (% Passing by Weight or Volume)

Sieve Size	PG 76 Mixtures		A-R Mixtures		Test Procedure
	Fine (PFC-F)	Coarse (PFC-C)	Fine (PFCR-F)	Coarse (PFCR-C)	
3/4"	–	100.0[1]	100.0[1]	100.0[1]	Tex-200-F
1/2"	100.0[1]	80.0–100.0	95.0–100.0	80.0–100.0	
3/8"	95.0–100.0	35.0–60.0	50.0–80.0	35.0–60.0	
#4	20.0–55.0	1.0–20.0	0.0–8.0	0.0–20.0	
#8	1.0–10.0	1.0–10.0	0.0–4.0	0.0–10.0	
#200	1.0–4.0	1.0–4.0	0.0–4.0	0.0–4.0	

1. Defined as maximum sieve size. No tolerance allowed.

Table 5
Mixture Design Properties

Mix Property	PG 76 Mixtures		A-R Mixtures		Test Procedure
	Fine (PFC-F) Requirements	Coarse (PFC-C) Requirements	Fine (PFCR-F) Requirements	Coarse (PFCR-C) Requirements	
Design gyrations (Ndesign)	50	50	50	50	Tex-241-F
Lab-molded density, %	78.0 Max	82.0 Max	82.0 Max	82.0 Max	Tex-207-F
Asphalt Binder Content, %	6.0–7.0	6.0–7.0	8.0–10.0	7.0–9.0	--
Hamburg Wheel test,[1] passes at 12.5 mm rut depth	10,000 Min[2]	Note 3	Note 3	Note 3	Tex-242-F
Drain-down, %	0.10 Max	0.10 Max	0.10 Max	0.10 Max	Tex-235-F
Fiber content, % by wt. of total PG 76 mixture	0.20–0.50	0.20–0.50	–	–	Calculated
Lime content, % by wt. of total aggregate	1.0[4]	1.0[4]	–	–	Calculated
CRM content, % by wt. of A-R binder	–	–	15.0 Min	15.0 Min	Calculated
Boil test[5]	–	–	–	–	Tex-530-C
Cantabro loss, %	20.0 Max	20.0 Max	20.0 Max	20.0 Max	Tex-245-F

1. Mold test specimens to Ndesign at the optimum asphalt binder content.
2. May be decreased when shown on the plans.
3. No specification value is required unless otherwise shown on the plans.
4. Unless otherwise shown on the plans or waived by the Engineer based on Hamburg Wheel results.
5. When shown on the plans. Used to establish baseline for comparison to production results.

4.4.2. **Job-Mix Formula Approval.** The job-mix formula (JMF) is the combined aggregate gradation, Ndesign level, and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When a compaction aid or foaming process is used, JMF1 may be designed and submitted to the Engineer without including the compaction aid or foaming process. When a compaction aid or foaming process is used, document the compaction aid or foaming process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than two trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities.**

4.4.2.1.1. **Providing Gyratory Compactor.** Furnish an SGC calibrated in accordance with Tex-241-F for molding production samples. Locate the SGC at the Engineer's field laboratory or make the SGC available to the Engineer for use in molding production samples.

4.4.2.1.2. **Gyratory Compactor Correlation Factors.** Use Tex-206-F, Part II, to perform a gyratory compactor correlation when the Engineer uses a different SGC. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1.** Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide an additional 25 lb. of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture when required in accordance with Table 5, and request that the Department perform the test.

4.4.2.1.4. **Supplying Aggregates.** Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.5. **Supplying Asphalt.** Provide at least 1 gal. of the asphalt material and enough quantities of any additives proposed for use.

4.4.2.1.6. **Ignition Oven Correction Factors.** Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 mo. old. Note that the asphalt content correction factor takes into account the percent fibers in the mixture so that the fibers are excluded from the binder content determination. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for quality assurance (QA) testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used and the correction factors are not more than 12 mo. old, unless otherwise directed.

4.4.2.1.7. **Boil Test.** When shown on the plans, perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production. Add lime or liquid antistripping agent, as directed, if signs of stripping exist.

4.4.2.1.8. **Trial Batch Production.** Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch including the compaction aid or foaming process, if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in accordance with Table 6. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment.** Use only equipment and materials proposed for use on the project to produce the trial batch. Provide documentation to verify the calibration or accuracy of the asphalt mass flow meter to measure the binder content. Verify that asphalt mass flow meter meets the requirements of 0.4% accuracy, when required, in accordance with Item 520, "Weighing and Measuring Equipment." The Engineer may require that the accuracy of the mass flow meter be verified based on quantities used.

4.4.2.1.10. **Trial Batch Quantity.** Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.11. **Number of Trial Batches.** Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.12. **Trial Batch Sampling.** Obtain a representative sample of the trial batch and split it into three equal portions in accordance with Tex-222-F. Label these portions as "Contractor," "Engineer," and "Referee." Deliver samples to the appropriate laboratory as directed.

4.4.2.1.13. **Trial Batch Testing.** Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in accordance with Table 6. Ensure the trial batch mixture is also in compliance with the requirements in accordance with Table 5. Use a Department-approved laboratory listed on the MPL to perform

the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. Provide an additional 25 lb. of the trial batch mixture if opting to have the Department perform the Hamburg Wheel test, if applicable, and request that the Department perform the test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2.** Evaluate the trial batch test results, determine the target mixture proportions, and submit as JMF2 after the Engineer grants full approval of JMF1 based on results from the trial batch. The mixture produced using JMF2 must meet the requirements in accordance with Tables 4 and 5. Verify that JMF2 meets the operational tolerances in accordance with Table 6.

4.4.2.1.15. **Mixture Production.** Use JMF2 to produce Lot 1 after receiving approval for JMF2.

4.4.2.1.16. **Development of JMF3.** Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.17. **JMF Adjustments.** If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the master gradation limits in accordance with Table 4; and
- be within the operational tolerances of JMF2 in accordance with Table 6.

4.4.2.1.18. **Requesting Referee Testing.** Use referee testing, if needed, in accordance with Section 3079.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 6
Operational Tolerances

Test Description	Test Method	Allowable Difference between JMF2 and JMF1 Target[1]	Allowable Difference from Current JMF and JMF2[2]	Allowable Difference between Contractor and Engineer[3]
Individual % retained for sieve sized larger than #200	Tex-200-F	Must be Within Master Grading Limits in accordance with Table 4	±3.0[4]	±5.0[4]
% passing the #200 sieve				±2.0[4]
Laboratory-molded density, %	Tex-207-F, Part VIII	±1.0	±1.0	±1.0
Asphalt binder content, %	Tex-236-F, Part I[5]	±0.3[6,7]	±0.3[4,6,7]	±0.3[6,7]
Drain-down, %	Tex-235-F	Note 8	Note 8	N/A
Boil test	Tex-530-C	Note 9	Note 9	N/A

1. JMF1 is the approved laboratory mixture design used for producing the trial batch. JMF2 is the approved mixture design developed from the trial batch used to produce Lot 1.
2. Current JMF is JMF3 or higher. JMF3 is the approved mixture design used to produce Lot 2.
3. Contractor may request referee testing only when values exceed these tolerances.
4. Only applies to mixture produced for Lot 1 and higher. Aggregate gradation is not allowed to be outside the limits shown in Table 4.
5. Ensure the binder content determination excludes fibers.
6. May be obtained from asphalt mass flow meter readouts as determined by the Engineer.
7. Binder content is not allowed to be outside the limits in accordance with Table 5.
8. Verify that Table 5 requirements are met.
9. When shown on the plans.

4.4.2.2. **Engineer's Responsibilities.**

4.4.2.2.1. **Superpave Gyratory Compactor.** The Engineer will use a Department SGC calibrated in accordance with Tex-241-F to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the

field laboratory or provide and use a Department SGC at an alternate location.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch.** The Engineer will review and verify conformance of the following information within two working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results;
- all required materials including aggregates, asphalt, and additives; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 3079.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after two working days, conditional approval of JMF1 will still be granted within two working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

The Contractor is authorized to produce a trial batch after the Engineer grants conditional approval of JMF1.

4.4.2.2.3. **Hamburg Wheel Testing.** At the Contractor's request, the Department will perform the Hamburg Wheel test on the laboratory mixture in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in accordance with Table 5. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

4.4.2.2.4. **Ignition Oven Correction Factors.** The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for QA testing during production in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 mo. old. The Engineer will verify that the asphalt content correction factor takes into account the percent fibers in the mixture so that the fibers are excluded from the binder content determination.

4.4.2.2.5. **Testing the Trial Batch.** Within one full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements in accordance with Table 6. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in accordance with Table 5.

The Engineer will have the option to perform Tex-530-C on the trial batch when shown on the plans. These results may be retained and used for comparison purposes during production.

4.4.2.2.6. **Full Approval of JMF1.** The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in accordance with Table 5.

The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. **Approval of JMF2.** The Engineer will approve JMF2 within one working day if the mixture meets the requirements in accordance with Tables 4, 5, and 6.

4.4.2.2.8. **Approval of Lot 1 Production.** The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2).

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes.** JMF3 and subsequent JMF changes are approved if they meet the master grading limits in accordance with Table 4, the asphalt binder content in accordance with Table 5, and are within the operational tolerances of JMF2 in accordance with Table 6.

4.4.2.2.10. **Binder Content Adjustments.** For JMF2 and above, the Engineer may require the Contractor to adjust the target binder content by no more than 0.3% from the current JMF.

4.5. **Production Operations.** Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification.

4.5.1. **Storage and Heating of Materials.** Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. **Mixing and Discharge of Materials.** Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed the maximum production temperatures in accordance with Table 7. The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures in accordance with Table 7.

Table 7
Maximum Production Temperature

High-Temperature Binder Grade[1]	Maximum Production Temperature
PG 76	345˚F
A-R Binder	345˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck and perform the test promptly.

4.6. **Hauling Operations.** Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent, when necessary, shown on the Department's MPL to coat the inside bed of the truck. Do not use diesel or any release agent not shown on the Department's MPL.

Use equipment for hauling as defined in Section 3079.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. **Placement Operations.** Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from

pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide within 6-in. of lane lines and are not placed in the wheel path, or as directed. Ensure that all finished surfaces will drain properly.

4.7.1. **Weather Conditions.**

4.7.1.1. **When Using a Thermal Imaging System.** The Contractor may pave any time the roadway is dry and the roadway surface temperature is at least 60°F unless otherwise approved or as shown on the plans; however, the Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Place mixtures when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 3079.4.7.3.1.2., "Thermal Imaging System."

Produce mixture with a target discharge temperature higher than 300°F and with a compaction aid to facilitate compaction when the air temperature is 70°F and falling.

4.7.1.1.1. **When Not Using a Thermal Imaging System.** When using a thermal camera instead of the thermal imaging system, place mixture when the roadway surface temperature is at or above 70°F unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the air temperature is 60°F and falling.

Produce mixture with a target discharge temperature higher than 300°F and with a compaction aid to facilitate compaction when the air temperature is 70°F and falling.

4.7.2. **Tack Coat.**

4.7.2.1. **Application.** Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply adequate overlap of the tack coat in the longitudinal direction during the placement of the mat to ensure bond of adjacent PFC mats, unless otherwise directed. Unless otherwise directed, avoid tacking the vertical faces of adjacent PFC mats in the longitudinal direction to avoid restricting lateral drainage. Apply tack coat to all transverse joints. Allow adequate time for emulsion to break completely before placing any material. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

4.7.2.2. **Sampling.** The Engineer will obtain at least one sample of the tack coat binder per project in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300, "Asphalts, Oils, and Emulsions." The Engineer will notify the Contractor when the sampling will occur and will witness the collection of the sample from the asphalt distributor immediately before use. Label the can with the corresponding lot and sublot numbers, producer, producer facility, grade, district, date sampled, and project information including highway and CSJ. For emulsions, the Engineer may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in Item 300, "Asphalts, Oils, and Emulsions."

4.7.3. **Lay-Down Operations.** Use the placement temperature in accordance with Table 8 to establish the minimum placement temperature of the mixture delivered to the paving operation.

Table 8
Minimum Mixture Placement Temperature

High-Temperature Binder Grade[1]	Minimum Placement Temperature (Before Entering Paving Operation)[2,3]
PG 76	280˚F
A-R Binder	280˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. The mixture temperature must be measured using a hand-held thermal camera or infrared thermometer nearest to the point of entry of the paving operation.
3. Minimum placement temperatures may be reduced 10°F if using a compaction aid.

4.7.3.1. **Thermal Profile.** Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F. Thermal profiles are not applicable in areas described in Section 3079.4.9.3.2., "Miscellaneous Areas."

4.7.3.1.1. **Thermal Segregation.**

4.7.3.1.1.1. **Moderate.** Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F.

4.7.3.1.1.2. **Severe.** Any areas that have a temperature differential greater than 50°F.

4.7.3.1.2. **Thermal Imaging System.** Review the output results when a thermal imaging system is used, and provide the report described in Tex-244-F to the Engineer daily. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system.

The Engineer may suspend subsequent paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe or moderate thermal segregation.

Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots daily or as requested by the Engineer.

4.7.3.1.2.1. **Thermal Camera.** When using a thermal camera instead of the thermal imaging system, take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Provide the Engineer with the thermal profile of every sublot within one working day of the completion of each lot. When requested by the Engineer, provide the electronic files generated using the thermal camera. Report the results of each thermal profile in accordance with Section 3079.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section.

4.7.3.2. **Windrow Operations.** Operate windrow pickup equipment so that when hot-mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.7.3.3. **Hauling Equipment.** Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability or when a thermal imaging system is used unless otherwise allowed.

4.7.3.4. **Screed Heaters.** Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 3079.4.9.3.3., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. **Compaction.** Roll the freshly placed PFC with as many steel-wheeled rollers as necessary, operated in static mode, to seat the mixture without excessive breakage of the aggregate and to provide a smooth surface and uniform texture. Do not use pneumatic rollers. Moisten the roller drums thoroughly with a soap and water solution to prevent adhesion. Use only water or an approved release agent on rollers, tamps, and

other compaction equipment unless otherwise directed.

Use Tex-246-F to test and verify that the compacted mixture has adequate permeability. Measure the water flow once per sublot at locations directed by the Engineer. The water flow rate must be less than 20 sec. Investigate the cause of the water flow rate test failures and take corrective actions during production and placement to ensure the water flow rate is less than 20 sec. Suspend production if two consecutive water flow rate tests fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Complete all compaction operations before the pavement temperature drops below 180°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 180°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. **Acceptance Plan.** Sample and test the hot-mix on a lot and sublot basis.

4.9.3. **Referee Testing.** The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if the differences between Contractor and Engineer test results exceed the operational tolerances in accordance with Table 6 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within five working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the sublot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than three referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

4.9.4. **Production Acceptance**.

4.9.4.1. **Production Lot.** A production lot consists of four equal sublots. The default quantity for Lot 1 is 1,000 ton; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 2,000 ton. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately three to four sublots are produced each day. The lot size will be between 1,000 ton and 4,000 ton. The Engineer may change the lot size before the Contractor begins any lot.

4.9.4.1.1. **Incomplete Production Lots.** If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Close all lots within five working days unless otherwise allowed.

4.9.4.2. **Production Sampling**.

4.9.4.2.1. **Mixture Sampling.** Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into three equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.4.2.1.1. **Random Sample.** At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.4.2.1.2. **Blind Sample.** For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The

Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.4.2.2. **Informational Shear Bond Strength Testing.** Select one random sublot from Lot 2 or higher for shear bond strength testing. Obtain full depth cores in accordance with Tex-249-F. Label the cores with the Control Section Job (CSJ), producer of the tack coat, mix type, shot rate, lot, and sublot number and provide to the Engineer. The Engineer will ship the cores to the Materials and Tests Division or district laboratory for shear bond strength testing. Results from these tests will not be used for specification compliance.

4.9.4.2.3. **Informational Hamburg and Overlay Testing.** Select one random sublot from Lot 2 or higher for Hamburg and Overlay testing during the first week of production. Obtain and provide the Engineer with approximately 90 lb. of mixture, sampled in accordance with Tex-222-F, in sealed containers, boxes, or bags labeled with the Control-Section-Job (CSJ), mixture type, lot, and sublot number. The Engineer will ship the mixture to the Materials and Tests Division for Hamburg and Overlay testing. Results from these tests will not be used for specification compliance.

4.9.4.2.4. **Asphalt Binder Sampling.** Obtain a 1 qt. (1 gal. for A-R binder) sample of the asphalt binder witness by the Engineer for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill and upstream from the introduction of any additives in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers, producer, producer facility, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain these samples for one year. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to the Materials and Tests Division to verify compliance with Item 300, "Asphalts, Oils, and Emulsions" and will retain the other split sample for one year.

4.9.4.3. **Production Testing.** The Contractor and Engineer must perform production tests in accordance with Table 9. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances in accordance with Table 6 for all sublots.

At any time during production, the Engineer may require the Contractor to verify the following based on quantities used:

- lime content (within ±0.1% of JMF), when PG binder is specified;
- fiber content (within ±0.03% of JMF), when PG binder is specified; and
- CRM content (within ±1.5% of JMF), when A-R binder is specified.

Maintain the in-line measuring device when A-R binder is specified to verify the A-R binder viscosity between 2,500 and 4,000 centipoise at 350°F unless otherwise approved. Record A-R binder viscosity at least once per hour and provide the Engineer with a daily summary unless otherwise directed.

If the aggregate mineralogy is such that Tex-236-F, Part I does not yield reliable results, the Engineer may allow alternate methods for determining the asphalt content and aggregate gradation. The Engineer will require the Contractor to provide evidence that results from Tex-236-F, Part I are not reliable before permitting an alternate method unless otherwise allowed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 9
Production and Placement Testing Frequency

Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency
Individual % retained for sieve sized larger than #200 % passing the #200 sieve	Tex-200-F	1 per sublot	1 per 12 sublots
Laboratory-molded density, %	Tex-207-F, Part VIII	1 per sublot	1 per lot
Asphalt binder content[1], %	Tex-236-F, Part I[2]	1 per sublot	1 per lot
Drain-down, %	Tex-235-F	1 per sublot	1 per 12 sublots
Boil test[3]	Tex-530-C	1 per project	1 per project
Moisture content	Tex-212-F, Part II	When directed	1 per project
Cantabro loss, %	Tex-245-F	1 per project (sample only)	1 per project
Overlay test	Tex-248-F	1 per project (sample only)	1 per project[4,9]
Hamburg Wheel test	Tex-242-F	1 per project (sample only)	1 per project[4,9]
Water flow test	Tex-246-F	1 per sublot	1 per project
Asphalt binder sampling	Tex-500-C, Part II	1 per lot (sample only)[5]	1 per project
Tack coat sampling and testing	Tex-500-C, Part III	N/A	1 per project
Thermal profile	Tex-244-F	1 per sublot,[6,7,8]	1 per project[7]

1. May be obtained from t mass flow meter readouts as determined by the Engineer.
2. Ensure the binder content determination excludes fibers.
3. When shown on the plans.
4. Testing performed by the Materials and Tests Division on sample obtained from Lot 2 or higher.
5. Obtain samples witness by the Engineer. The Engineer will retain these samples for one year.
6. To be performed in the presence of the Engineer when using the thermal camera, unless otherwise approved.
7. Not required when a thermal imaging system is used.
8. When using the thermal imaging system, the test report must include the temperature measurements taken in accordance with Tex-244-F.
9. Testing performed by the Materials and Tests Division for informational purposes only.

4.9.4.4. **Operational Tolerances.** Control the production process within the operational tolerances in accordance with Table 6. Suspend production and placement operations when production or placement test results exceed the tolerances in accordance with Table 6 unless otherwise allowed. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.4.5. **Individual Loads of Hot-Mix.** The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances in accordance with Table 6, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.5. **Placement Acceptance.**

4.9.5.1. **Placement Lot.** A placement lot consists of four placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.5.2. **Miscellaneous Areas.** Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations such as driveways, mailbox turnouts, crossovers, gores, spot level-up

areas, and other similar areas. The specified layer thickness is based on the rate of 90 lb. per square yard for each inch of pavement unless another rate is shown on the plans. Miscellaneous areas are not subject to thermal profiles testing.

4.9.5.3. **Recovered Asphalt Dynamic Shear Rheometer (DSR).** The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Materials and Tests Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with Tex-211-F.

4.9.5.4. **Irregularities.** Identify and correct irregularities, including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) areas where the mixture does not bond to the existing pavement.

If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.6. **Exempt Production.** When the anticipated daily production is less than 100 ton, all QC and QA sampling and testing are waived. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is more than 100 ton but less than 250 ton;
- total production for the project is less than 2,500 ton;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements. All other specification requirements apply, and the Engineer will perform acceptance tests for production and placement in accordance with Table 9.

For exempt production:

- produce, haul, place, and compact the mixture as directed by the Engineer; and
- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target density as tested by the Engineer.

4.9.7. **Ride Quality.** Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

5.1. **PFC Hot-Mix Asphalt.** Permeable friction course (PFC) hot-mix will be measured by the ton of composite mixture which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment.

5.2. **Tack Coat.** Tack coat will be measured at the applied temperature by strapping the tank before and after road application and determining the net volume in gallons from the calibrated distributor. The Engineer will witness all strapping operations for volume determination. All tack, including emulsions, will be measured by the gallon applied.

The Engineer may allow the use of a metering device to determine asphalt volume used and application rate if the device is accurate to within 1.5% of the strapped volume.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3079.5.1., "PFC Hot-Mix Asphalt," will be paid for at the unit bid price for "Permeable friction course Hot Mix Asphalt" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3079.5.2., "Tack Coat," will be paid for at the unit bid price for "Tack Coat" of the tack coat provided. These prices are full compensation for materials, placement, equipment, labor, tools, and incidentals.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

Special Specification 3081
Thin Overlay Mixtures

1. DESCRIPTION

Construct a thin surface course composed of a compacted mixture of aggregate and asphalt binder mixed hot in a mixing plant. Produce a thin overlay mixture (TOM) with a minimum lift thickness of 1/2 in. for a Type F mixture and 3/4 in. for a Type C mixture.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate.** Furnish aggregates from sources that conform to the requirements in accordance with Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Do not use reclaimed asphalt pavement (RAP) or recycled asphalt shingles (RAS). Supply aggregates that meet the definitions in accordance with Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests in accordance with Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis in accordance with Tex-200-F, Part II.

2.1.1. **Coarse Aggregate.** Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance;
- approved only when tested by the Engineer;
- once approved, do not add material to the stockpile unless otherwise approved; and
- allow 30 calendar days for the Engineer to sample, test, and report results.

2.1.1.1. **Blending Class A and Class B Aggregates.** Class B aggregate meeting all other requirements in blending Class A and B aggregates to meet a Class A requirement, ensure that at least 50% by weight, or volume if required, of all aggregates used in the mixture design retained on the No. 8 sieve comes from the Class A

aggregate source, unless otherwise shown on the plans. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Class B aggregate may be disallowed when shown on the plans.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 8 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 8 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.1.2. **Micro-Deval Abrasion.** The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC, unless otherwise directed. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:
Mg_{est} = magnesium sulfate soundness loss
$RSSM$ = Rated Source Soundness Magnesium
MD_{act} = actual Micro-Deval percent loss
$RSMD$ = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Soils and Aggregates Section of the Materials and Tests Division, and additional testing may be required before granting approval.

2.1.2. **Intermediate Aggregate.** Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used that are free from organic impurities. The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used that meet the requirements in accordance with Table 1 unless otherwise approved.

If 10% or more of the stockpile is retained on the No. 4 sieve, verify that it meets the requirements in accordance with Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

2.1.3. **Fine Aggregate.** Fine aggregates consist of manufactured sands and screenings. Natural sands are not allowed in any mixture. Fine aggregate stockpiles must meet the fine aggregate properties in accordance with Table 1 and the gradation requirements in accordance with Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Use fine aggregate from coarse aggregate sources that meet the requirements in accordance with Table 1 unless otherwise approved.

If 10% or more of the stockpile is retained on the No. 4 sieve, verify that it meets the requirements in accordance with Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A	A[1]
Deleterious material, %, Max	Tex-217-F, Part I	1.5
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note [2]
Los Angeles abrasion, %, Max	Tex-410-A	30
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	20
Crushed face count,[3] %, Min	Tex-460-A, Part I	95
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Sand equivalent, %, Min	Tex-203-F	45

1. Surface Aggregate Classification of "A" is required unless otherwise shown on the plans.
2. Used to estimate the magnesium sulfate soundness loss in accordance with Section 3081.2.1.1.2., "Micro-Deval Abrasion."
3. Only applies to crushed gravel.

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler.** Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, or hydrated lime. Mineral filler is allowed unless otherwise shown on the plans. Fly ash is not permitted unless otherwise shown on the plans. Use no more than 2% hydrated lime unless otherwise shown on the plans. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3, unless otherwise shown on the plans.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

2.3. **Baghouse Fines.** Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. **Asphalt Binder.** Furnish performance-graded (PG) asphalt binder with a high temperature grade of PG 76 unless otherwise shown in the plans and a low temperature grade as shown on the plans, in accordance with Section 300.2.10., "Performance-Graded Binders."

2.5. **Tack Coat.** Furnish CSS-1H, SS-1H, EBL, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized tack coat materials listed on the Department's Tracking Resistant Asphalt Interlayer (TRAIL) MPL may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

2.6. **Additives.** Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

2.6.1. **Lime and Liquid Antistripping Agent.** When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Use no more than 1% hydrated lime when using crushed gravel. Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.6.2. **Compaction Aid.** Compaction Aid is defined as a department-approved chemical warm mix additive denoted as "chemical additive" on the Department's materials producer list (MPL) that is used to facilitate mixing and compaction of HMA.

Compaction Aid is allowed for use on all projects. Compaction aid is required when shown on the plans or as required in Section 3081.4.7.1., "Weather Conditions."

Warm mix foaming processes, denoted as "foaming process" on the Department-approved MPL, may be used to facilitate mixing and compaction of HMA; however warm mix foaming processes are not defined as a Compaction Aid.

2.7. **Recycled Materials.** Recycled materials are not allowed for use.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

4.1. **Certification.** Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 4. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests. Provide AGG101 certified specialists for aggregate testing.

Table 4
Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate Testing				
Sampling	Tex-221-F	✓	✓	1A/AGG101
Dry sieve	Tex-200-F, Part I	✓	✓	1A/AGG101
Washed sieve	Tex-200-F, Part II	✓	✓	1A/AGG101
Deleterious material	Tex-217-F, Part I	✓	✓	AGG101
Decantation	Tex-217-F, Part II	✓	✓	AGG101
Los Angeles abrasion	Tex-410-A		✓	Department
Magnesium sulfate soundness	Tex-411-A		✓	Department
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Crushed face count	Tex-460-A	✓	✓	AGG101
Flat and elongated particles	Tex-280-F	✓	✓	AGG101
Sand equivalent	Tex-203-F	✓	✓	AGG101
Organic impurities	Tex-408-A	✓	✓	AGG101
Methylene blue test	Tex-252-F		✓	Department
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Drain-down	Tex-235-F	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F, Part II	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	1A
Overlay test	Tex-248-F		✓	Department
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Boil test[4]	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F, Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Gradation & asphalt binder content[2]	Tex-236-F, Part I	✓	✓	1A
Drain-down	Tex-235-F	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F, Part II	✓	✓	1A/AGG101
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Overlay test	Tex-248-F	✓	✓	Department
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Boil test[4]	Tex-530-C	✓	✓	1A
Absorn recovery	Tex-211-F		✓	Department
5. Placement Testing				
Establish rolling pattern	Tex-207-F, Part IV	✓		1B
In-place density (nuclear method)	Tex-207-F, Part III	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Thermal profile	Tex-244-F	✓	✓	1B
Water flow test	Tex-246-F	✓	✓	1B

1. Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 3081.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.
3. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.
4. When shown on the plans.

4.2. **Reporting and Responsibilities.** Use Department-provided templates to record and calculate all test data, including mixture design, production and placement QC/QA, control charts, and thermal profiles. Obtain the current version of the templates at https://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The maximum allowable time for the Contractor and Engineer to exchange test data is as given in Table 5 unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Section 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 5
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[2]			
Moisture content[3]			
Boil test[5]			
Production Quality Assurance			
Gradation[3]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[3]			
Laboratory-molded density[1]			
Hamburg Wheel test[4]			
Overlay test[4]			
Boil test[5]			
Binder tests[4]			
Placement Quality Control			
Thermal profile[1]	Contractor	Engineer	1 working day of completion of the lot
Water flow[1]			
Placement Quality Assurance			
Thermal profile[3]	Engineer	Contractor	1 working day of completion of the lot
Aging ratio[4]			
Water flow			

1. These tests are required on every sublot.
2. Optional test. When performed on split samples, report the results as soon as they become available.
3. To be performed at the frequency specified and in accordance with Table 13 or as shown on the plans.
4. To be reported as soon as the results become available.
5. When shown on the plans.

Use the procedures described in Tex-233-F to plot the results of all quality control (QC) and quality assurance (QA) testing. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. **Quality Control Plan (QCP).** Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting. Receive approval of the QCP before pre-paving meeting. Include the following items in the QCP:

4.3.1. **Project Personnel**. For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and
- current copies of certification documents for individuals performing specified QC functions.

4.3.2. **Material Delivery and Storage.** For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

4.3.3. **Production.** For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, lime, liquid antistrip, compaction aid, foaming process);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

4.3.4. **Loading and Transporting.** For loading and transporting, include:

- type and application method for release agents; and
- truck loading procedures to avoid segregation.

4.3.5. **Placement and Compaction.** For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., production rate, paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver, while avoiding physical and thermal segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., speed, operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.4. **Mixture Design.**

4.4.1. **Design Requirements.** The Contractor may design the mixture using a Texas Gyratory Compactor (TGC) or a Superpave Gyratory Compactor (SGC) unless otherwise shown on the plans. Use the typical weight design example given in Tex-204-F, Part I, when using a TGC. Use the Superpave mixture design procedure provided in Tex-204-F, Part IV, when using a SGC. Design the mixture to meet the requirements in accordance with Tables 1, 2, 3, 6, and 7.

4.4.1.1. **Target Laboratory-Molded Density When the TGC Is Used.** Design the mixture at a 97.5% target laboratory-molded density or in accordance with Table 7.

4.4.1.2. **Design Number of Gyrations (Ndesign) When the SGC Is Used.** Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 7. The Ndesign level may be reduced to no less than 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test, and the Department will perform the Overlay test and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test and Overlay test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test and Overlay test results on the laboratory mixture design.

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- the target laboratory-molded density (or Ndesign level when using the SGC);
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 6
Master Gradation Limits (% Passing by Weight or Volume) and Volumetric Requirements

Sieve Size	Coarse (TOM-C)	Fine (TOM-F)
1/2"	100.0[1]	100.0[1]
3/8"	95.0–100.0	98.0–100.0
#4	40.0–60.0	70.0–95.0
#8	17.0–27.0	40.0–65.0
#16	5.0–27.0	20.0–45.0
#30	5.0–27.0	10.0–35.0
#50	5.0–27.0	10.0–20.0
#200	5.0–9.0	2.0–12.0
Asphalt Binder Content,[2] % Min		
-	6.0	6.5
Design VMA,[3] % Min		
-	16.0	16.5
Production (Plant-Produced) VMA,[3] % Min		
-	15.5	16.0

1. Defined as maximum sieve size. No tolerance allowed.
2. Unless otherwise shown on the plans or approved by the Engineer.
3. Voids in Mineral Aggregates (VMA).

Table 7
Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, % (TGC)	Tex-207-F	97.5[1]
Design gyrations (Ndesign for SGC)	Tex-241-F	50[2]
Hamburg Wheel test, passes at 12.5 mm rut depth for PG 76 mixtures	Tex-242-F	20,000 Min
Overlay test, Critical Fracture Energy, lb.-in/sq. in	Tex-248-F	1.5 Min
Overlay test, Crack Progression Rate	Tex-248-F	0.40 Max
Drain-down, %	Tex-235-F	0.20 Max

1. Unless otherwise shown on the plans or approved by the Engineer. Laboratory-molded density requirement using the TGC may be waived when approved by the Engineer.

2. May be adjusted within the range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor. Laboratory-molded density requirement using the SGC may be waived when approved by the Engineer.

4.4.1 **Job-Mix Formula Approval.** The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or Ndesign level), and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When a compaction aid or foaming process is used, JMF1 may be designed and submitted to the Engineer without including the compaction aid or foaming process. When a compaction aid or foaming process is used, document the compaction aid or foaming process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than two trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities.**

4.4.2.1.1. **Providing Gyratory Compactor.** Use a TGC calibrated in accordance with Tex-914-K when electing or required to design the mixture in accordance with Tex-204-F, Part I, for molding production samples. Furnish an SGC calibrated in accordance with Tex-241-F when electing or required to design the mixture in accordance with Tex-204-F, Part IV, for molding production samples. Locate the SGC if used, at the Engineer's field laboratory or make the SGC available to the Engineer for use in molding production samples.

4.4.2.1.2. **Gyratory Compactor Correlation Factors.** Use Tex-206-F, Part II, to perform a gyratory compactor correlation when the Engineer uses a different gyratory compactor. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1.** Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 25 lb. of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture, and request that the Department perform the test. Provide approximately 60 lb. of the design mixture to perform the Overlay test.

4.4.2.1.4. **Supplying Aggregates.** Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.5. **Supplying Asphalt.** Provide at least 1 gal. of the asphalt material and enough quantities of any additives proposed for use.

4.4.2.1.6. **Ignition Oven Correction Factors.** Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 mo. old. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for QA testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used and the correction factors are not more than 12 mo. old, unless otherwise directed.

4.4.2.1.7. **Boil Test.** When shown on the plans, perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production.

4.4.2.1.8. **Trial Batch Production.** Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch, including the compaction aid or foaming process, if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in accordance with Table 8. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment.** Use only equipment and materials proposed for use on the project to produce the trial batch.

4.4.2.1.10. **Trial Batch Quantity.** Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.11. **Number of Trial Batches.** Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.12. **Trial Batch Sampling.** Obtain a representative sample of the trial batch and split it into three equal portions in accordance with Tex-222-F. Label these portions as "Contractor," "Engineer," and "Referee." Deliver samples to the appropriate laboratory as directed.

4.4.2.1.13. **Trial Batch Testing.** Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in accordance with Table 8. Ensure the trial batch mixture is also in compliance with the requirements in accordance with Tables 6 and 7. Use a Department-approved laboratory listed on the MPL to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. Provide approximately 25 lb. of the trial batch mixture if opting to have the Department perform the Hamburg Wheel test, and request that the Department perform the test. Obtain and provide approximately 60 lb. of trial batch mixture in sealed containers, boxes, or bags labeled with the CSJ, mixture type, lot, and sublot number in accordance with Tex-222-F for the Overlay test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test and Overlay test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2.** Evaluate the trial batch test results after the Engineer grants full approval of JMF1 based on results from the trial batch, determine the optimum mixture proportions, and submit as JMF2. Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The mixture produced using JMF2 must meet the requirements in accordance with Tables 6 and 7. Verify that JMF2 meets the operation tolerances of JMF1 in accordance with Table 8.

4.4.2.1.15. **Mixture Production.** Use JMF2 to produce Lot 1 after receiving approval for JMF2 and a passing result from the Department's or a Department-approved laboratory's Hamburg Wheel test and the Department's Overlay test on the trial batch. If desired, proceed to Lot 1 production, once JMF2 is approved, at the Contractor's risk without receiving the results from either the Department's Hamburg Wheel test or Overlay test on the trial batch.

Notify the Engineer if electing to proceed without Hamburg Wheel test and Overlay test results from the trial batch. Note that the Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test or Overlay test to be removed and replaced at the Contractor's expense.

4.4.2.1.16. **Development of JMF3.** Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.17. **JMF Adjustments.** If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the master gradation limits in accordance with Table 6; and
- be within the operational tolerances of JMF2 in accordance with Table 8.

4.4.2.1.18. **Requesting Referee Testing.** Use referee testing, if needed, in accordance with Section 3081.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 8
Operational Tolerances

Description	Test Method	Allowable Difference between JMF2 and JMF1 Target[1]	Allowable Difference from Current JMF and JMF2[2]	Allowable Difference between Contractor and Engineer[3]
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be Within Master Grading Limits in accordance with Table 6	±3.0[4,5]	±5.0
Individual % retained for sieves smaller than #8 and larger than #200			±3.0[4,5]	±3.0
% passing the #200 sieve			±2.0[4,5]	±1.6
Asphalt binder content, %[6]	Tex-236-F	±0.3	±0.3[5]	±0.3
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±1.0
Laboratory-molded bulk specific gravity		N/A	N/A	±0.020
VMA, % Min	Tex-204-F	Note 7	Note 7	N/A
Theoretical Max specific (Rice) gravity	Tex-227-F	N/A	N/A	±0.020
Drain-down, %	Tex-235-F	Note 8	Note 8	N/A

1. JMF1 is the approved laboratory mixture design used for producing the trial batch. JMF2 is the approved mixture design developed from the trial batch used to produce Lot 1.
2. Current JMF is JMF3 or higher. JMF3 is the approved mix design used to produce Lot 2.
3. Contractor may request referee testing only when values exceed these tolerances.
4. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
5. Only applies to mixture produced for Lot 1 and higher.
6. Binder content is not allowed to be outside the limits in accordance with Table 6. May be obtained from asphalt meter readouts as determined by the Engineer.
7. Verify that Table 6 requirements are met.
8. Verify that Table 7 requirements are met.

4.4.2.2. **Engineer's Responsibilities.**

4.4.2.2.1. **Gyratory Compactor.** For mixtures designed in accordance with Tex-204-F, Part I, the Engineer will use a Department TGC, calibrated in accordance with Tex-914-K, to mold samples for trial batch and production testing.

For mixtures designed in accordance with Tex-204-F, Part IV, the Engineer will use a Department SGC, calibrated in accordance with Tex-241-F, to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch.** The Engineer will review and verify conformance of the following information within two working days of receipt:

- the Contractor's mix design report (JMF1);
- the Department-provided Overlay test results;
- the Contractor-provided Hamburg Wheel test results;
- all required materials including aggregates, asphalt, and additives; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test and department provided Overlay test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with

Section 3081.2.1.1., "Micro-Deval Abrasion." If the Engineer's test results are pending after two working days, conditional approval of JMF1 will still be granted within two working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

The Contractor is authorized to produce a trial batch after the Engineer grants conditional approval of JMF1.

4.4.2.2.3. **Hamburg Wheel and Overlay Testing of JMF1.** If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the laboratory mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 7. The Engineer will perform the Overlay test and mold samples in accordance with Tex-248-F to verify compliance with the Overlay test requirements in Table 7. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel and Overlay test results on the laboratory mixture design.

4.4.2.2.4. **Ignition Oven Correction Factors.** The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for QA testing during production in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 mo. old.

4.4.2.2.5. **Testing the Trial Batch.** Within one full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements in accordance with Table 8. The Engineer will mold samples in accordance with Tex-242-F if the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture to verify compliance with Hamburg Wheel test requirements in Table 7. The Engineer will mold samples for the Overlay test in accordance with Tex-248-F to verify compliance with the Overlay test requirement in Table 7.

The Engineer will have the option to perform Tex-530-C on the trial batch when shown on the plans. These results may be retained and used for comparison purposes during production.

4.4.2.2.6. **Full Approval of JMF1.** The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in accordance with Tables 6 and 7. The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. **Approval of JMF2.** The Engineer will approve JMF2 within one working day if the mixture meets the requirements in accordance with Table 6, 7, and 8.

4.4.2.2.8. **Approval of Lot 1 Production.** The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2) as soon as a passing result is achieved from the Department's or a Department-approved laboratory's Hamburg Wheel test and the Department's Overlay test on the trial batch. The Contractor may proceed at its own risk with Lot 1 production without the results from the Hamburg Wheel test or Overlay test on the trial batch.

If the Department's or Department-approved laboratory's sample from the trial batch fails the Hamburg Wheel test or Overlay test, the Engineer will suspend production until further Hamburg Wheel tests or Overlay tests meet the specified values. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test or Overlay test to be removed and replaced at the Contractor's expense.

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes.** JMF3 and subsequent JMF changes are approved if they meet the master grading limits and asphalt binder content shown in Table 6 and are within the operational tolerances of JMF2 shown in accordance with Table 8.

4.5. **Production Operations.** Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification.

4.5.1. **Storage and Heating of Materials.** Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. **Mixing and Discharge of Materials.** Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed the maximum production temperatures in accordance with Table 9. The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures listed in Table 9.

Table 9
Maximum Production Temperature

High-Temperature Binder Grade[1]	Max Production Temperature
PG 76	345˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck and perform the test promptly.

4.6. **Hauling Operations.** Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department's MPL to coat the inside bed of the truck when necessary. Do not use diesel or any release agent not shown on the Department's MPL.

Use equipment for hauling as defined in Section 3081.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. **Placement Operations.** Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Place mixture so that longitudinal joints on the surface course coincide within 6-in. of lane lines and are not placed in the wheel path, or as directed, and offset longitudinal joints of successive courses of hot-mix by at least 6-in. Ensure that all finished surfaces will drain properly. Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 10 to determine the compacted lift thickness. The thickness determined is based on the rate of 110–115 lb. per square inch. for each inch of pavement unless otherwise shown on the plans.

Table 10
Compacted Lift Thickness

Mixture Type	Compacted Lift Thickness[1]	
	Min (in.)	Max (in.)
TOM-C	0.75	1.25
TOM-F	0.5	1.00

1. Compacted target lift thickness will be specified on the plans.

4.7.1. **Weather Conditions.**

4.7.1.1. **When Using a Thermal Imaging System.** The Contractor may pave any time the roadway is dry and the roadway surface temperature is at least 60°F unless otherwise approved or as shown on the plans; however, the Engineer may restrict the Contractor from paving surface mixtures if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 3081.4.7.3.1.2., "Thermal Imaging System."

Produce mixture with a target discharge temperature higher than 300°F and with a compaction aid to facilitate compaction when the air temperature is 70°F and falling

4.7.1.2. **When Not Using a Thermal Imaging System.** When using a thermal camera instead the thermal imaging system, place mixture when the roadway surface temperature is at or above 70°F unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the air temperature is 70°F and falling.

Produce mixture with a target discharge temperature higher than 300°F and with a compaction aid to facilitate compaction when the air temperature is 70°F and falling.

4.7.2. **Tack Coat.**

4.7.2.1. **Application.** Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area, unless otherwise specified on the plans. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply the tack coat to all surfaces that will come in contact with the subsequent HMA placement unless otherwise directed. Apply adequate overlap of the tack coat in the longitudinal direction during placement of the mat to ensure bond of adjacent mats, unless otherwise directed. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. The Engineer may suspend paving operations until there is adequate coverage. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

4.7.2.2. **Sampling.** The Engineer will obtain at least one sample of the tack coat binder per project in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300, "Asphalts, Oils, and Emulsions." The Engineer will notify the Contractor when the sampling will occur and will witness the collection of the sample from the asphalt distributor immediately before use. Label the can with the corresponding lot and sublot numbers, producer, producer facility, grade, district, date sampled, and project information including highway and CSJ. For emulsions, the Engineer may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in Item 300, "Asphalts, Oils, and Emulsions."

4.7.3. **Lay-Down Operations.** Use the placement temperatures in accordance with Table 11 to establish the minimum placement temperature of mixture delivered to the paving operation.

Table 11
Minimum Mixture Placement Temperature

High-Temperature Binder Grade[1]	Min Placement Temperature (Before Entering Paving Operation)2,3
PG 76	280°F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. The mixture temperature must be measured using a hand-held thermal camera or infrared thermometer nearest to the point of entry of the paving operation.
3. Minimum placement temperatures may be reduced 10°F if using a compaction aid.

4.7.3.1. **Thermal Profile.** Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F.

4.7.3.1.1. **Thermal Segregation.**

4.7.3.1.1.1. **Moderate.** Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F.

4.7.3.1.1.2. **Severe.** Any areas that have a temperature differential greater than 50°F.

4.7.3.1.2. **Thermal Imaging System.** Review the output results when a thermal imaging system is used, and provide the report described in accordance with Tex-244-F to the Engineer daily. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system.

The Engineer may suspend subsequent paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe or moderate thermal segregation.

Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots daily or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera.** When using a thermal camera instead of the thermal imaging system, take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Evaluate areas with moderate thermal segregation by performing water flow testing in accordance with Tex-246-F and verify the water flow is greater than 120 sec. Provide the Engineer with the thermal profile of every sublot within one working day of the completion of each lot. When requested by the Engineer, provide the electronic files generated using the thermal camera. Report the results of each thermal profile in accordance with Section 3081.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project, unless the thermal imaging system is used. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section. Evaluate areas with severe thermal segregation by performing water flow testing in accordance with Tex-246-F and verify the water flow is greater than 120 sec. Remove and replace the material in any areas that have both severe thermal segregation and a failing result for water flow test unless otherwise directed.

4.7.3.2. **Windrow Operations.** Operate windrow pickup equipment so that when hot-mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.7.3.3. **Hauling Equipment.** Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture. End dump trucks are only allowed when used in conjunction with an MTD with remixing capability unless otherwise allowed.

4.7.3.4. **Screed Heaters.** Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 3081.4.9.3.1.1., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. **Compaction.** Roll the freshly placed mixture with as many steel-wheeled rollers as necessary to ensure adequate compaction without excessive breakage of the aggregate and to provide a smooth surface and uniform texture. Operate each roller in static mode for TOM-F mixtures only. Do not use pneumatic-tire rollers. Use the control strip method given in accordance with Tex-207-F, Part IV, to establish the rolling pattern. Thoroughly moisten the roller drums with a soap and water solution to prevent adhesion. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Use Tex-246-F to measure water flow to verify the mixture is adequately compacted. Measure the water flow once per sublot at locations directed by the Engineer. Take additional water flow measurements when the minimum temperature of the uncompacted mat is below the temperature requirements in accordance with Table 12.

Table 12
Minimum Uncompacted Mat Temperature Requiring Additional Water Flow Measurements

High-Temperature Binder Grade[1]	Min Temperature of the Uncompacted Mat Allowed Before Initial Break Down Rolling[2,3]
PG 76	<270˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. The surface of the uncompacted mat must be measured using a hand-held thermometer or infrared thermometer.
3. Minimum uncompacted mat temperature requiring a water flow measurement may be reduced 10°F if using a compaction aid.

Use Tex-246-F to measure water flow to verify the mixture is adequately compacted at confined longitudinal joints as directed by the Engineer.

The water flow rate should be greater than 120 sec. Investigate the cause of the water flow rate test failures and take corrective actions during production and placement to ensure the water flow rate is greater than 120 sec. Suspend production if two consecutive water flow rate tests fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Complete all compaction operations before the pavement temperature drops below 180°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 180°F when approved.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. **Acceptance Plan.** Sample and test the hot-mix asphalt on a lot and sublot basis.

4.9.1. **Referee Testing.** The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if the differences between Contractor and Engineer test results exceed the maximum allowable difference in accordance with Table 8 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within five working days after receiving test results from the Engineer. Referee tests will be performed only on the sublot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than three referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

The Materials and Tests Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample.

4.9.2. **Production Acceptance.**

4.9.2.1. **Production Lot.** A production lot consists of four equal sublots. The default quantity for Lot 1 is 500 ton; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 2,000 ton. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately three to four sublots are produced each day. The lot size will be between 500 ton and 2,000 ton. The Engineer may change the lot size before the Contractor begins any lot.

4.9.2.1.1. **Incomplete Production Lots.** If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Close all lots within five working days unless otherwise allowed.

4.9.2.2. **Production Sampling.**

4.9.2.2.1. **Mixture Sampling.** Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into three equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample.** At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample.** For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.2.2.2. **Informational Methylene Blue Testing.** During the project and at random, obtain and provide the Engineer with approximately 50 lb. of each fine aggregate and approximately 20 lb. of all mineral fillers used to produce the mixture. Label the samples with the Control Section Job (CSJ), mixture type, and approximate lot and sublot number corresponding to when the sample was taken. The Engineer will ship the samples to the Materials and Tests Division for Methylene Blue testing in accordance with Tex-252-F. Results from these tests will not be used for specification compliance.

4.9.2.2.3. **Asphalt Binder Sampling.** Obtain a 1-qt. sample of the asphalt binder witnessed by the Engineer for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill and upstream from the introduction of any additives in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers, producer, producer facility location, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain these samples for one year. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor.

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to the Materials and Tests Division to verify compliance with Item 300, "Asphalts, Oils, and Emulsions," and will retain the other split sample for 1 yr.

4.9.2.3. **Production Testing.** The Contractor and Engineer must perform production tests in accordance with Table 13. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances listed in accordance with Table 8 for all sublots. Take immediate corrective action if the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 98.0% when using the SGC or less than 96.5% or greater than 98.5% when using the TGC, to bring

the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F, Part I does not yield reliable results. Provide evidence that results from Tex-236-F, Part I are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 13
Production and Placement Testing Frequency

Description	Test Method	Min Contractor Testing	Min Engineer Testing
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	1 per sublot	1 per 12 sublots[1]
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	N/A	1 per sublot[1]
Laboratory-molded bulk specific gravity			
VMA	Tex-204-F		
Moisture content	Tex-212-F, Part II	When directed	
Theoretical maximum specific (Rice) gravity	Tex-227-F, Part II	N/A	1 per sublot[1]
Asphalt binder content[2]	Tex-236-F, Part I	1 per sublot	1 per lot[1]
Overlay test[3]	Tex-248-F	N/A	1 per project
Hamburg Wheel test	Tex-242-F	N/A	1 per project
Thermal profile	Tex-244-F	1 per sublot[4,5,6]	1 per project[5]
Asphalt binder sampling and testing	Tex-500-C, Part II	1 per lot (sample only)[7]	1 per project
Tack coat sampling and testing	Tex-500-C, Part III	N/A	1 per project
Boil test[8]	Tex-530-C	1 per sublot[9]	1 per project
Water flow	Tex-246-F		
Methylene blue test[10]	Tex-252-F	1 per project (sample only)	

1. For production defined in Section 3081.4.9.4., "Exempt Production," the Engineer will test one per day if 100 ton or more are produced. For Exempt Production, no testing is required with less than 100 ton are produced.
2. May be obtained from asphalt flow meter readout as determined by the Engineer.
3. Testing performed by the Materials and Tests Division on sample obtained from Lot 2 or higher.
4. To be performed in the presence of the Engineer when a thermal camera is used, unless otherwise approved.
5. Not required when a thermal imaging system is used.
6. When using the thermal imaging system, the test report must include the temperature measurements taken in accordance with Tex-244-F.
7. Obtain samples witnessed by the Engineer. The Engineer will retain these samples for 1 yr.
8. When shown on the plans.
9. To be performed in the presence of the Engineer, unless otherwise directed.
10. Testing performed by the Materials and Tests Division for informational purposes only.

4.9.2.4. **Operational Tolerances.** Control the production process within the operational tolerances in accordance with Table 8. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.2.4.1. **Gradation.** Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size in accordance with Table 6. A sublot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances in accordance with Table 8 for three consecutive sublots on the same sieve or four consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

4.9.2.4.2. **Asphalt Binder Content.** A sublot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values in accordance with Table 8. Suspend production when two or

more sublots within a lot are out of operational tolerance or below the minimum asphalt binder content specified in accordance with Table 6 unless otherwise directed. Suspend production and shipment of mixture if the Engineer's or Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any sublot or is less than the minimum asphalt content allowed in accordance with Table 6.

4.9.2.4.3. **Voids in Mineral Aggregates (VMA).** The Engineer will determine the VMA for every sublot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any sublot is less than the minimum VMA requirement for production in accordance with Table 6. Suspend production and shipment of the mixture if the Engineer's VMA results on two consecutive sublots are below the minimum VMA requirement for production in accordance with Table 6.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production in accordance with Table 6. In addition to suspending production, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment.

4.9.2.4.4. **Hamburg Wheel.** The Engineer may perform a Hamburg Wheel on plant produced mixture at any time during production. In addition to testing production samples, the Engineer may obtain cores and perform the Hamburg Wheel test on any area of the roadway where rutting is observed. Suspend production until further Hamburg Wheel meet the specified values when the production or core samples fail to meet the Hamburg Wheel criteria in accordance with Table 7. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel to be removed and replaced at the Contractor's expense.

If the Department's or Department-approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Materials and Tests Division will perform the Hamburg Wheel and determine the final disposition of the material in question based on the Department's test results.

4.9.2.5. **Individual Loads of Hot-Mix.** The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances in accordance with Table 8, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.3. **Placement Acceptance.**

4.9.3.1. **Placement Lot.** A placement lot consists of four placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.3.1.1. **Recovered Asphalt Dynamic Shear Rheometer (DSR).** The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Materials and Tests Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with Tex-211-F.

4.9.3.1.2. **Irregularities.** Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. The Engineer may require the Contractor to remove and replace (at the

Contractor's expense) areas of the pavement that contain irregularities if the Engineer determines that the irregularity will adversely affect pavement performance. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) areas where the mixture does not bond to the existing pavement.

The Engineer may require the Contractor to immediately suspend operations if irregularities are detected or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.4. **Exempt Production.** When the anticipated daily production is less than 100 ton, all QC and QA sampling and testing are waived. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is more than 100 ton but less than 250 ton;
- total production for the project is less than 2,500 ton;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements. All other specification requirements apply, and the Engineer will perform acceptance tests for production and placement in accordance with Table 13.

For exempt production:

- produce, haul, place, and compact the mixture as directed by the Engineer; and
- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target density as tested by the Engineer.

4.9.5. **Ride Quality.** Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

5.1. **TOM Hot-Mix Asphalt.** TOM hot-mix will be measured by the ton of composite mixture, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.2. **Tack Coat.** Tack coat will be measured at the applied temperature by strapping the tank before and after road application and determining the net volume in gallons from the calibrated distributor. The Engineer will witness all strapping operations for volume determination. All tack, including emulsions, will be measured by the gallon applied.

The Engineer may allow the use of a metering device to determine asphalt volume used and application rate if the device is accurate within 1.5% of the strapped volume.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3081.5.1., "TOM Hot-Mix Asphalt," will be paid for at the unit bid price for "Thin Overlay Mixture" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, removing pavement marking and markers, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3081.5.2., "Tack Coat," will be paid for at the unit bid price for "Tack Coat" of the tack coat provided. These prices are full compensation for materials, placement, equipment, labor, tools, and incidentals.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

Special Specification 3082
Thin Bonded Friction Courses

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) surface course composed of a warm spray-applied polymer modified emulsion membrane followed immediately with a compacted permeable mixture of aggregate, asphalt binder, and additives mixed hot in a mixing plant.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate.** Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse or fine aggregate. Do not use intermediate or fine aggregate in PFC mixtures. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in accordance with Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. **Coarse Aggregate.** Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance;
- approved only when tested by the Engineer;
- once approved, do not add material to the stockpile unless otherwise approved; and
- allow 30 calendar days for the Engineer to sample, test, and report results.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes, unless otherwise shown on the plans. SAC requirements apply to aggregates used on surfaces other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates.** To prevent crushing of the Class B aggregate when blending, Class B aggregate may be blended with a Class A aggregate to meet requirements for Class A materials if the Department's BRSQC rated source soundness magnesium (RSSM) rating for the Class B aggregate is less than the Class A aggregate or if the RSSM rating for the Class B aggregate is less than or equal to 10%. Use the rated values for hot mix asphaltic concrete (HMAC) published in the BRSQC. When blending Class A and B aggregates to meet a Class A requirement, ensure that at least 50% by weight, or volume if required, of all the aggregates used in the mixture design retained on the No. 4 sieve comes from the Class A aggregate source, unless otherwise shown on the plans. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Class B aggregate may be disallowed when shown on the plans.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.1.2. **Micro-Deval Abrasion.** The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC, unless otherwise directed. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
$RSSM$ = Rated Source Soundness Magnesium
$MD_{act.}$ = actual Micro-Deval percent loss
$RSMD$ = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Soils and Aggregates Section of the Materials and Tests Division, and additional testing may be required before granting approval.

2.1.2. **Fine Aggregate.** Fine aggregates consist of manufactured sands and screenings. Fine aggregate stockpiles must meet the fine aggregate properties in accordance with Table 1 and the gradation requirements in accordance with Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Do not use field sand or other uncrushed fine aggregate. Use fine aggregate from coarse aggregate sources that meet the requirements shown in accordance with Table 1 unless otherwise approved.

Table 1
Coarse Aggregate Quality Requirements

Property	Test Method	Requirement
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.0
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note [1]
Los Angeles abrasion, %, Max	Tex-410-A	30
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	20
Crushed face count[2], %, Min	Tex-460-A, Part I	95
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate Properties		
Sand Equivalent, %, Min	Tex-203-F	45
Methylene Blue, mg/g, Max	Tex-252-F	10.0

1. Used to estimate the magnesium sulfate soundness loss in accordance with section 3082.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler.** Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, or hydrated lime. Fly ash is not allowed unless otherwise shown on the plans. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime, unless otherwise shown on the plans. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-252-F to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in accordance with Table 3, unless otherwise shown on the plans.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

2.3. **Baghouse Fines.** Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. **Asphalt Binder.** Furnish the type and grade of binder specified on the plans that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions."

2.4.1. **Performance-Graded (PG) Binder.** Provide an asphalt binder with a high-temperature grade of PG 76 and low-temperature grade as shown on the plans in accordance with Section 300.2.10., "Performance-Graded Binders," when PG binder is specified.

2.4.2. **Asphalt-Rubber (A-R) Binder.** Provide A-R binder that meets the Type I or Type II requirements of Section 300.2.9., "Asphalt-Rubber Binders," when A-R is specified unless otherwise shown on the plans. Use at least 15.0% by weight of Crumb Rubber Modifier (CRM) that meets the Grade B or Grade C requirements of Section 300.2.7., "Crumb Rubber Modifier," unless otherwise shown on the plans. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal. Provide the Engineer with documentation such as the bill of lading showing the quantity of CRM used in the project unless otherwise directed.

2.5. **Membrane.** Provide a smooth and homogeneous polymer modified emulsion meeting the requirements in accordance with Table 4.

Table 4
Polymer Modified Emulsion Requirements

Test on Emulsion	Test Method	Min	Max
Viscosity @ 77°F, SSF	T 72	20	100
Storage Stability,[1] %	T 59		1
Demulsibility (for anionic emulsions), 35 mL of 0.02 N CaCl2, %	T 59	55	
Demulsibility (for cationic emulsions), 35 mL 0.8% Sodium dioctyl sulfosuccinate, %	T 59	55	
Sieve Test,[2] %	T 59		0.05
Distillation Test:[3] Residue by distillation, % by wt. Oil portion of distillate, % by vol.	T 59	63	0.5
Test on Residue from Distillation	**Test Method**	**Min**	**Max**
Elastic Recovery @ 50°F, 50 mm/min., %	Tex-539-C	60	
Penetration @ 77°F, 100 g, 5 sec, 0.1 mm	T 49	100	150

1. After standing undisturbed for 24 hr., the surface must be smooth, must not exhibit a white or milky colored substance, and must be a homogeneous color throughout.
2. May be required by the Engineer only when the emulsion cannot be easily applied in the field.
3. The temperature on the lower thermometer should be brought slowly to 350°F ±10°F and maintained at this temperature for 20 min. The total distillation should be complete in 60 ±5 min. from the first application of heat.

2.6. **Additives.** Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

2.6.1. **Fibers.** Provide cellulose or mineral fibers when PG binder is specified. Do not use fibers when A-R binder is specified. Submit written certification to the Engineer that the fibers proposed for use meet the requirements of DMS-9204, "Fiber Additives for Bituminous Mixtures." Fibers may be pre-blended into the binder at the asphalt supply terminal unless otherwise shown on the plans.

2.6.2. **Lime Mineral Filler.** Add lime as mineral filler at a rate of 1.0% by weight of the total dry aggregate in accordance with Item 301, "Asphalt Antistripping Agents," unless otherwise shown on the plans or waived by the Engineer based on Hamburg Wheel test results. Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.6.3. **Lime and Liquid Antistripping Agent.** When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum. Lime added as mineral filler will count towards the total quantity of lime specified when the plans require lime to be added as an antistripping agent.

2.6.4. **Compaction Aid.** Compaction Aid is defined as a Department-approved chemical warm mix additive denoted as "chemical additive" on the Department's material producer list (MPL) that is used to facilitate mixing and compaction of HMA.

Compaction aid is allowed for use on all projects. Compaction aid is required when shown on the plans or as required in Section 3082.4.7.1., "Weather Conditions."

Warm mix foaming processes, denoted as "foaming process" on the Department-approved MPL, may be used to facilitate mixing and compaction of HMA; however warm mix processes are not defined as a Compaction Aid.

2.7. **Recycled Materials.** Recycled materials are not allowed for use.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement." When A-R binder is specified, equip the hot-mix plant with an in-line viscosity-measuring device located between the blending unit and the mixing drum. Provide a means to calibrate the asphalt mass flow meter on-site when a meter is used.

3.1. **Placement Equipment.** Provide a paver that meets all the requirements listed below.

3.1.1. **Paver.** Furnish a paver that will spray the membrane, apply the PFC mixture, and level the surface of the mat in a single pass. Configure the paver so that the mixture is placed no more than 5 sec. after the membrane is applied. Ensure the paver does not support the weight of any portion of hauling equipment other than the connection. Provide loading equipment that does not transmit vibrations or other motions to the paver that adversely affects the finished pavement quality. Equip the paver with an automatic dual longitudinal-grade control system and an automatic transverse-grade control system.

3.1.1.1. **Tractor Unit.** Supply a tractor unit that can push or propel vehicles, dumping directly into the finishing machine to obtain the desired lines and grades to eliminate any hand finishing. Equip the unit with a hitch to maintain contact between the hauling equipment's rear wheels and the finishing machine's pusher rollers while mixture is unloaded.

3.1.1.2. **Membrane Storage Tank and Distribution System.** Equip the paver with an insulated storage tank with a minimum capacity of 900 gal. Provide a metered mechanical pressure sprayer on the paver to apply a uniform membrane at the specified rate. Locate the spray bar on the paver so that the membrane is applied immediately in front of the screed unit. Provide a read-out device on the paver to monitor the membrane application rate.

Furnish a volumetric calibration and strap stick for the tank in accordance with Tex-922-K, Part I, unless otherwise directed. Calibrate the tank within the previous 5 yr. of the date first used on the project. The Engineer may verify calibration accuracy in accordance with Tex-922-K, Part II.

3.1.1.3. **Screed.** Provide a variable width vibratory screed that meets Item 320, "Equipment for Asphalt Concrete Pavement."

3.1.2. **Material Transfer Device (MTD).** Provide the specified type of MTD when shown on the plans. Ensure MTDs provide a continuous, uniform mixture flow to the asphalt paver.

3.1.3. **Rollers.** Provide steel-wheel rollers meeting the requirements of Item 210, "Rolling," except provide rollers weighing a minimum of 10 ton for each roller required. Operate rollers in static (non-vibrating) mode unless otherwise allowed.

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

4.1. **Certification.** Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 5. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests. Provide AGG101 certified specialists for aggregate testing.

Table 5

Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate Testing				
Sampling	Tex-221-F	✓	✓	1A/AGG101
Dry sieve	Tex-200-F, Part I	✓	✓	1A/AGG101
Washed sieve	Tex-200-F, Part II	✓	✓	1A/AGG101
Deleterious material	Tex-217-F, Parts I & III	✓	✓	AGG101
Decantation	Tex-217-F, Part II	✓	✓	AGG101
Los Angeles abrasion	Tex-410-A		✓	Department
Magnesium sulfate soundness	Tex-411-A		✓	Department
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Crushed face count	Tex-460-A	✓	✓	AGG101
Flat and elongated particles	Tex-280-F	✓	✓	AGG101
Methylene blue test	Tex-252-F		✓	Department
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Membrane sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I, VI, & VIII	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F, Part II	✓	✓	2
Drain-down	Tex-235-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Boil test[4]	Tex-530-C	✓	✓	1A
Cantabro loss	Tex-245-F	✓	✓	1A
4. Production Testing				
Control charts	Tex-233-F	✓	✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Gradation & asphalt binder content[2]	Tex-236-F, Part I	✓	✓	1A
Moisture content	Tex-212-F, Part II	✓	✓	1A/AGG101
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Drain-down	Tex-235-F	✓	✓	1A
Boil test[4]	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	Department
5. Placement Testing				
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Thermal profile	Tex-244-F	✓	✓	1B
Water flow test	Tex-246-F	✓	✓	1B

1. Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 3082.4.5., "Production Operations," for exceptions to using an ignition oven.
3. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.
4. When shown on the plans.

4.2. **Reporting and Responsibilities.** Use Department-provided templates to record and calculate all test data, including mixture design, production and placement tests, control charts, and thermal profiles. Obtain the current version of the templates at https://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The Contractor and Engineer must exchange test data within the maximum allowable time in accordance with Table 6 unless otherwise approved. The Engineer and the

Contractor will immediately report to the other party any test result that requires suspension of production or placement or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Section 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 6
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[1]			
Moisture content[2]			
Drain-down[1]			
Boil test[4]			
Production Quality Assurance			
Gradation[2]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[2]			
Laboratory-molded density[2]			
Hamburg Wheel test[3]			
Boil test[4]			
Drain-down[2]			
Binder tests[3]			
Placement Quality Control			
Thermal profile[1]	Contractor	Engineer	1 working day of completion of the lot
Water flow[1]			
Membrane application rate[2]			
Placement Quality Assurance			
Thermal profile[2]	Engineer	Contractor	1 working day of completion of the lot
Aging ratio[3]			
Water flow[2]			
Membrane application rate[2]			

1. These tests are required on every sublot.
2. To be performed at the frequency in accordance with Table 14 or as shown on the plans.
3. To be reported as soon as the results become available.
4. When shown on the plans

Use the procedures described in Tex-233-F, when directed, to plot the results of all production and placement testing. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. **Quality Control Plan (QCP).** Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting, when directed. Receive approval of the QCP before pre-paving meeting. Include the following items in the QCP:

4.3.1. **Project Personnel.** For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and
- current copies of certification documents for individuals performing specified QC functions.

4.3.2. **Material Delivery and Storage.** For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant

operations;

- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

4.3.3. **Production.** For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, lime, liquid antistrip, compaction aid, foaming process, fibers);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

4.3.4. **Loading and Transporting.** For loading and transporting, include:

- type and application method for release agents; and
- truck loading procedures to avoid segregation.

4.3.5. **Placement and Compaction.** For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., production rate, paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver while avoiding physical and thermal segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., speed, operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.4. **Mixture Design.**

4.4.1. **Design Requirements.** Use the design procedure provided in Tex-204-F, unless otherwise shown on the plans. Design the mixture to meet the requirements in accordance with Tables 1, 2, 3, 7, 8, and 9. Use a Superpave Gyratory Compactor (SGC) at 50 gyrations as the design number of gyrations (Ndesign).

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- the membrane application rate based on design volumetrics;
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 7
Master Gradation Limits (% Passing by Weight or Volume)
and Laboratory Mixture Design Properties

Sieve Size	Permeable Friction Course		Thin Bonded Friction Course		
	Fine (PFC-F)	Coarse (PFC-C and PFCR-C)	Type A	Type B	Type C
3/4"	–	100.0[1]	–	–	100[1]
1/2"	100.0[1]	80.0–100.0	–	100[1]	75–100
3/8"	95.0–100.0	35.0–60.0	100[1]	75–100	55–80
#4	20.0–55.0	1.0–20.0	35–55	22–36	22–36
#8	1.0–10.0	1.0–10.0	19–30	19–30	19–30
#16	–	–	14–25	14–24	14–24
#50	–	–	7–14	7–14	7–14
#200	1.0–4.0	1.0–4.0	4–6	4–6	4–6

1. Defined as maximum sieve size. No tolerance allowed.

Table 8
Mixture Design Properties

Mixture Property	Test Method	PG 76 Mixtures		A-R Mixtures	Thin Bonded Friction Course		
		Fine (PFC-F)	Coarse (PFC-C)	Coarse (PFCR-C)	Type A	Type B	Type C
Asphalt binder content, %	–	6.0–7.0	6.0–7.0	7.0–9.0	5.0–5.8	4.8–5.6	4.8–5.6
Film thickness, microns	–	–	–	–	9.0 Min	9.0 Min	9.0 Min
Design gyrations (Ndesign)	Tex-241-F	50	50	50	50	50	50
Laboratory-molded density, %	Tex-207-F	78.0 Max	82.0 Max	82.0 Max	92.0 Max	92.0 Max	92.0 Max
Hamburg Wheel test,[1] passes at 12.5 mm rut depth	Tex-242-F	10,000 Min	Note 2	Note 2	Note 2	Note 2	Note 2
Drain-down, %	Tex-235-F	0.10 Max	0.10 Max	0.10 Max	0.10 Max	0.10 Max	0.10 Max
Fiber content, % by wt. of total PG 76 mixture	Calculated	0.20–0.50	0.20-0.50	–	–	–	–
Lime content, % by wt. of total aggregate	Calculated	1.0[3]	1.0[3]	–	Note 4	Note 4	Note 4
CRM content, % by wt. of A-R binder	Calculated	–	–	15.0 Min	–	–	–
Boil test[5]	Tex-530-C	–	–	–	–	–	–
Cantabro loss, %	Tex-245-F	20.0 Max	20.0 Max	20.0 Max	20.0 Max	20.0 Max	20.0 Max

1. Mold test specimens to Ndesign at the optimum asphalt binder content.
2. No specification value is required unless otherwise shown on the plans.
3. Unless otherwise shown on the plans or waived by the Engineer based on Hamburg Wheel results.
4. Lime may be required when shown on the plans.
5. When shown on the plans. Used to establish baseline for comparison to production results.

4.4.2. **Job-Mix Formula Approval.** The job-mix formula (JMF) is the combined aggregate gradation, Ndesign level, and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When a compaction aid or foaming process is used, JMF1 may be designed and submitted to the Engineer without including the compaction aid or foaming process. When a compaction aid or foaming process is used, document the compaction aid or foaming process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than two trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities.**

4.4.2.1.1. **Providing Superpave Gyratory Compactor.** Furnish an SGC calibrated in accordance with Tex-241-F for molding production samples. Locate the SGC at the Engineer's field laboratory or make the SGC available to the Engineer for use in molding production samples.

4.4.2.1.2. **Gyratory Compactor Correlation Factors.** Use Tex-206-F, Part II, to perform a gyratory compactor

correlation when the Engineer uses a different SGC. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1.** Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide an additional 25 lb. of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture when required in accordance with Table 8, and request that the Department perform the test.

4.4.2.1.4. **Supplying Aggregates.** Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.5. **Supplying Asphalt.** Provide at least 1 gal. of the asphalt material and enough quantities of any additives proposed for use.

4.4.2.1.6. **Ignition Oven Correction Factors.** Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 mo. old. Note that the asphalt content correction factor takes into account the percent fibers in the mixture so that the fibers are excluded from the binder content determination. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for quality assurance testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used and the correction factors are not more than 12 mo. old, unless otherwise directed.

4.4.2.1.7. **Boil Test.** When shown on the plans, perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production. Add lime or liquid antistripping agent as directed if signs of stripping exist.

4.4.2.1.8. **Trial Batch Production.** Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch, including the compaction aid or foaming process, if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in accordance with Table 9. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment.** Use only equipment and materials proposed for use on the project to produce the trial batch. Provide documentation to verify the calibration or accuracy of the asphalt mass flow meter to measure the binder content. Verify that asphalt mass flow meter meets the requirements of 0.4 % accuracy, when required, in accordance with Item 520, "Weighing and Measuring Equipment." The Engineer may require that the accuracy of the mass flow meter be verified based on quantities used.

4.4.2.1.10. **Trial Batch Quantity.** Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.11. **Number of Trial Batches.** Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.12. **Trial Batch Sampling.** Obtain a representative sample of the trial batch and split it into three equal portions in accordance with Tex-222-F. Label these portions as "Contractor," "Engineer," and "Referee." Deliver samples to the appropriate laboratory as directed.

4.4.2.1.13. **Trial Batch Testing.** Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in accordance with Table 9. Ensure the trial batch mixture is also in compliance with the requirements in accordance with Tables 7 and 8. Use a Department-approved laboratory listed on the MPL to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2.** Evaluate the trial batch test results, determine the target mixture proportions, and

submit as JMF2 after the Engineer grants full approval of JMF1 based on results from the trial batch. Verify that JMF2 meets the mixture requirements in accordance with Table 9.

4.4.2.1.15. **Mixture Production.** After receiving approval for JMF2, use JMF2 to produce Lot 1.

4.4.2.1.16. **Development of JMF3.** Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.17. **JMF Adjustments.** If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the master gradation limits in accordance with Table 7
- meet the binder content limits in accordance with Table 8; and
- be within the operational tolerances of JMF2 in accordance with Table 9.

4.4.2.1.18. **Requesting Referee Testing.** Use referee testing, if needed, in accordance with Section 3082.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 9
Operational Tolerances

Test Description	Test Method	Allowable Difference between JMF2 and JMF1 Target[1]	Allowable Difference from Current JMF and JMF2[2]	Allowable Difference between Contractor and Engineer[3]
Individual % retained for sieve sized larger than #200	Tex-200-F	Must be Within Master Grading Limits in accordance with Table 7	±3.0[4]	±5.0[4]
% passing the #200 sieve			±2.0[4]	±3.0[4]
Laboratory-molded density, %	Tex-207-F, Part VIII	±1.0	±1.0	±1.0
Asphalt binder content, %	Tex-236-F, Part I[5]	±0.3[6,7]	±0.3[4,6,7]	±0.3[6,7]
Drain-down, %	Tex-235-F	Note 8	Note 8	N/A
Boil test	Tex-530-C	Note 9	Note 9	N/A
Membrane application rate	Tex-247-F	±0.02	±0.02	N/A

1. JMF1 is the approved laboratory mixture design used for producing the trial batch. JMF2 is the approved mixture design developed from the trial batch used to produce Lot 1.
2. Current JMF is JMF3 or higher. JMF3 is the approved mixture design used to produce Lot 2.
3. Contractor may request referee testing only when values exceed these tolerances.
4. Only applies to mixture produced for Lot 1 and higher. Aggregate gradation is not allowed to be outside the limits in accordance with Table 7.
5. Ensure the binder content determination excludes fibers.
6. May be obtained from asphalt mass flow meter readouts as determined by the Engineer.
7. Binder content is not allowed to be outside the limits shown in Table 8.
8. Verify that Table 8 requirements are met.
9. When shown on the plans.

4.4.2.2. **Engineer's Responsibilities.**

4.4.2.2.1. **Superpave Gyratory Compactor.** The Engineer will use a Department SGC calibrated in accordance with Tex-241-F to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch.** The Engineer will review and verify conformance of the following information within two working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results, if applicable;
- all required materials including aggregates, asphalt, and additives; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with

Section 3082.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after two working days, conditional approval of JMF1 will still be granted within two working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

The Contractor is authorized to produce a trial batch after the Engineer grants conditional approval of JMF1.

4.4.2.2.3. **Hamburg Wheel Testing.** At the Contractor's request, the Department will perform the Hamburg Wheel test on the laboratory mixture in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in accordance with Table 8. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel results on the laboratory mixture design.

4.4.2.2.4. **Ignition Oven Correction Factors.** The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for quality assurance testing during production in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 mo. old. The Engineer will verify that the asphalt content correction factor takes into account the percent fibers in the mixture so that the fibers are excluded from the binder content determination.

4.4.2.2.5. **Testing the Trial Batch.** The Engineer will sample and test the trial batch within one full working day to ensure that the mixture meets the requirements in accordance with Table 9. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in accordance with Table 8.

The Engineer will have the option to perform Tex-530-C on the trial batch when shown on the plans. These results may be retained and used for comparison purposes during production.

4.4.2.2.6. **Full Approval of JMF1.** The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in accordance with Tables 7 and 8.

The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. **Approval of JMF2.** The Engineer will approve JMF2 within one working day if the mixture meets the requirements in accordance with Tables 7, 8, and 9.

4.4.2.2.8. **Approval of Lot 1 Production.** The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2).

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes.** JMF3 and subsequent JMF changes are approved if they meet the master grading and asphalt binder content shown in accordance with Tables 7 and 8 and are within the operational tolerances of JMF2 in accordance with Table 9.

4.4.2.2.10. **Binder Content Adjustments.** For JMF2 and above, the Engineer may require the Contractor to adjust the target binder content by no more than 0.3% from the current JMF.

4.5. **Production Operations.** Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification.

4.5.1. **Storage and Heating of Materials.** Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. **Mixing and Discharge of Materials.** Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed the maximum production temperatures in accordance with Table 10. The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures in accordance with Table 10.

Table 10
Maximum Production Temperature

High-Temperature Binder Grade[1]	Max Production Temperature
PG 76	345˚F
A-R Binder	345˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck and perform the test promptly.

4.6. **Hauling Operations.** Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department's MPL to coat the inside bed of the truck when necessary. Do not use diesel or any release agent not shown on the Department's MPL.

Use equipment for hauling as defined in Section 3082.4.7.3.2., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. **Placement Operations.** Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Do not allow any loose mixture onto the prepared surface before application of the membrane. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide within 6-in. of lane lines and are not placed in the wheel path, or as directed, and offset longitudinal joints of successive courses of hot-mix by at least 6-in. Ensure that all finished surfaces will drain properly.

4.7.1. **Weather Conditions.**

4.7.1.1. **When Using a Thermal Imaging System.** The Contractor may pave any time the roadway is dry and the roadway surface temperature is at least 60°F unless otherwise approved or as shown on the plans; however, the Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Place mixtures when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 3082.4.7.3.1.2., "Thermal Imaging System."

Produce mixture with a target discharge temperature higher than 300°F and with a compaction aid to facilitate compaction when the air temperature is 70°F and falling.

4.7.1.2. **When Not Using a Thermal Imaging System.** When using a thermal camera instead of the thermal imaging system, place mixture when the roadway surface temperature is at or above 70°F unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the air temperature is 60°F and falling.

Produce mixture with a target discharge temperature higher than 300°F and with a compaction aid to facilitate compaction when the air temperature is 70°F and falling.

4.7.2. **Application of Membrane.** Apply the membrane at the rates in accordance with Table 11 unless otherwise directed. Spray the membrane using a metered mechanical pressure spray bar at a temperature of 140°F to 180°F. Monitor the membrane application rate and make adjustments to the rate when directed. Verify that the spray bar is capable of applying the membrane at a uniform rate across the entire paving width. Apply adequate overlap of the tack coat in the longitudinal direction during placement of the mat to ensure bond of adjacent mats, unless otherwise directed. Unless otherwise directed, avoid tacking the vertical faces of adjacent PFC mats in the longitudinal direction to avoid restricting lateral drainage. Apply tack coat to all transverse joints. Do not let the wheels or other parts of the paving machine contact the freshly applied membrane. Do not dilute the membrane at the terminal, in the field, or at any other location before use. Do not allow any loose mixture onto the prepared surface before application of the membrane.

Table 11
Membrane Application Rate Limits, (Gal. per square yard)

Mix Type	Lift Thickness	Membrane Rate
Permeable Friction Course	1-1/2 in.	0.30–0.33
	1-1/4 in.	0.27–0.30
	1 in.	0.25–0.28
	3/4 in.	0.22–0.25
Thin Bonded Friction Course	3/4 in.	0.17–0.27
	5/8 in.	0.16–0.24
	1/2 in.	0.14–0.20

4.7.2.1. **Non-uniform Application of Membrane**. Stop application if it is not uniform due to streaking, ridging, pooling, or flowing off the roadway surface. Verify equipment condition including plugged nozzles on the spray bar, operating procedures, application temperature, and material properties. Determine and correct the cause of non-uniform application.

4.7.2.2. **Test Strips.** The Engineer may perform independent tests to confirm Contractor compliance and may require testing differences or failing results to be resolved before resuming production.

The Engineer may cease operations and require construction of test strips at the Contractor's expense if any of the following occurs:

- non-uniformity of application continues after corrective action;
- in three consecutive shots, application rate differs by more than 0.03 gal. per square yard from the rate

directed; or

- any shot differs by more than 0.05 gal. per square yard from the rate directed.

The Engineer will approve the test strip location. The Engineer may require additional test strips until the membrane application meets specification requirements.

4.7.3. **Lay-Down Operations.** Use the placement temperature in accordance with Table 12 to establish the minimum placement temperature of the mixture delivered to the paving operation.

Table 12
Min Mixture Placement Temperature

High-Temperature Binder Grade[1]	Min Placement Temperature (Before Entering Paving Operation)[2,3]
PG 76	280˚F
A-R Binder	280˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. The mixture temperature must be measured using a hand-held thermal camera or infrared thermometer nearest to the point of entry of the paving operation.
3. Minimum placement temperatures may be reduced 10°F if using a compaction aid.

4.7.3.1. **Thermal Profile.** Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F. Thermal profiles are not applicable in areas described in Section 3082.4.9.8., "Miscellaneous Areas."

4.7.3.1.1. **Thermal Segregation.**

4.7.3.1.1.1. **Moderate.** Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F.

4.7.3.1.1.2. **Severe.** Any areas that have a temperature differential greater than 50°F.

4.7.3.1.2. **Thermal Imaging System.** Review the output results when a thermal imaging system is used, and provide the report described in Tex-244-F to the Engineer daily unless otherwise directed. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system.

The Engineer may suspend subsequent paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe or moderate thermal segregation.

Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots daily or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera.** When using the thermal camera instead of the thermal imaging system, take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Provide the Engineer with the thermal profile of every sublot within one working day of the completion of each lot. When requested by the Engineer, provide the electronic files generated using the thermal camera. Report the results of each thermal profile in accordance with Section 3082.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project unless the thermal imaging system is used. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section.

4.7.3.2. **Hauling Equipment.** Use live bottom or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability or when a thermal imaging system is used unless otherwise allowed.

4.7.3.3. **Screed Heaters.** Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 3082.4.9.9., "Recovered

Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. **Compaction.** Roll the freshly placed mixture with as many steel-wheeled rollers as necessary, operated in static mode, to seat the mixture without excessive breakage of the aggregate and to provide a smooth surface and uniform texture. Do not use pneumatic rollers. Use the control strip method given in Tex-207-F, Part IV, to establish the rolling pattern. Moisten the roller drums thoroughly with a soap and water solution to prevent adhesion. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

For PFC mixtures, use Tex-246-F to test and verify that the compacted mixture has adequate permeability. Measure the water flow once per sublot at locations directed by the Engineer. The water flow rate should be less than 20 sec. Investigate the cause of the water flow rate test failures and take corrective actions during production and placement to ensure the water flow rate is less than 20 sec. Suspend production if two consecutive water flow rate tests fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Complete all compaction operations before the pavement temperature drops below 180°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 180°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. **Acceptance Plan.** Sample and test the hot-mix on a lot and sublot basis.

4.9.1. **Referee Testing.** The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if the differences between Contractor and Engineer test results exceed the operational tolerances in accordance with Table 9 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within five working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the sublot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than three referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

4.9.2. **Production Acceptance.**

4.9.2.1. **Production Lot.** A production lot consists of four equal sublots. The default quantity for Lot 1 is 1,000 ton; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 2,000 ton. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately three to four sublots are produced each day. The lot size will be between 1,000 ton and 4,000 ton. The Engineer may change the lot size before the Contractor begins any lot.

4.9.2.1.1. **Incomplete Production Lots.** If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Close all lots within five working days unless otherwise allowed.

4.9.2.2. **Production Sampling.**

4.9.2.2.1. **Mixture Sampling.** Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into three equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample.** At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample.** For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.2.2.2. **Informational Hamburg and Overlay Testing.** Select one random sublot from Lot 2 or higher for Hamburg and Overlay testing during the first week of production. Obtain and provide the Engineer with approximately 90 lb. of mixture, sampled in accordance with Tex-222-F, in sealed containers, boxes, or bags labeled with the Control-Section-Job (CSJ), mixture type, lot, and sublot number. The Engineer will ship the mixture to the Materials and Tests Division for Hamburg and Overlay testing. Results from these tests will not be used for specification compliance.

4.9.2.2.3. **Asphalt Binder Sampling**. Obtain a 1-qt. (1 gal. for A-R binder) sample of the asphalt binder witness by the Engineer for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill and upstream from the introduction of any additives in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers, producer, producer facility, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain these samples for one year. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor.

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to the Materials and Tests Division to verify compliance with Item 300, "Asphalts, Oils, and Emulsions" and will retain the other split sample for 1 yr.

4.9.2.3. **Membrane Sampling.** The Engineer will obtain a 1-qt. sample of the polymer modified emulsion for each lot of mixture produced in accordance with Tex-500-C, Part III. The Engineer will notify the Contractor when the sampling will occur and will witness the collection of the sample. Obtain the sample at approximately the same time the mixture random sample is obtained. Label the can with the corresponding lot and sublot numbers, producer, producer facility, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain theses samples for two months.

At least once per project, the Engineer will collect split samples of the polymer modified emulsion. The Engineer will submit one split sample to the Materials and Tests Division to verify compliance with Item 300, "Asphalts, Oils, and Emulsions" and will retain the other split sample for two months. The Engineer may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in Item 300, "Asphalts, Oils, and Emulsions."

4.9.2. **Production Testing.** The Contractor and Engineer must perform production tests in accordance with Table 13. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances in accordance with Table 9 for all sublots.

At any time during production, the Engineer may require the Contractor to verify the following based on quantities used:

- lime content (within ±0.1% of JMF), when PG binder is specified;
- fiber content (within ±0.03% of JMF), when PG binder is specified; and
- CRM content (within ±1.5% of JMF), when A-R binder is specified.

Maintain the in-line measuring device when A-R binder is specified to verify the A-R binder viscosity between

2,500 and 4,000 centipoise at 350°F unless otherwise approved. Record A-R binder viscosity at least once per hour and provide the Engineer with a daily summary unless otherwise directed.

If the aggregate mineralogy is such that Tex-236-F Part I does not yield reliable results, the Engineer may allow alternate methods for determining the asphalt content and aggregate gradation. The Engineer will require the Contractor to provide evidence that results from Tex-236-F, Part I are not reliable before permitting an alternate method unless otherwise allowed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 13
Production and Placement Testing Frequency

Description	Test Method	Min Contractor Testing Frequency	Min Engineer Testing Frequency
Individual % retained for sieve sized larger than #200	Tex-200-F	1 per sublot	1 per 12 sublots
% passing the #200 sieve			
Laboratory-molded density, %	Tex-207-F, Part VIII	1 per sublot	1 per lot
Asphalt binder content[1], %	Tex-236-F, Part I[2]	1 per sublot	1 per lot
Drain-down, %	Tex-235-F	1 per sublot	1 per 12 sublots
Boil test[3]	Tex-530-C	1 per project	1 per project
Membrane application rate	Tex-247-F	1 per lot	1 per 12 sublots
Moisture content	Tex-212-F, Part II	When directed	1 per project
Cantabro loss, %	Tex-245-F	1 per project (sample only)	1 per project
Overlay test	Tex-248-F	1 per project (sample only) [10]	1 per project[4]
Hamburg Wheel test	Tex-242-F	1 per project (sample only)[10]	1 per project[4]
Water flow test[5]	Tex-246-F	1 per sublot	1 per project
Asphalt binder sampling	Tex-500-C, Part II	1 per lot (sample only)[6]	1 per project
Membrane sampling and testing	Tex-500-C, Part III	N/A	1 per project
Thermal profile	Tex-244-F	1 per sublot[7,8,9]	1 per project[8]

1. May be obtained from asphalt mass flow meter readouts as determined by the Engineer.
2. Ensure the binder content determination excludes fibers.
3. When shown on the plans.
4. When required according to mixture type and requirements in accordance with Table 8.
5. Only required for PFC mixtures.
6. Obtain samples witness by the Engineer. The Engineer will retain these samples for 1 yr.
7. To be performed in the presence of the Engineer when using the thermal camera, unless otherwise approved.
8. Not required when a thermal imaging system is used.
9. When using the thermal imaging system, the test report must include the temperature measurements taken in accordance with Tex-244-F.
10. Testing performed by the Materials and Tests Division for informational purposes only.

4.9.3. **Operational Tolerances.** Control the production process within the operational tolerances in accordance with Table 9. Suspend production and placement operations when production or placement test results exceed the tolerances in accordance with Table 9 unless otherwise allowed. The Engineer will allow suspended production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.4. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances in accordance with Table 9 , payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.5. **Placement Acceptance.**

4.9.6. **Placement Lot.** A placement lot consists of four placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.7. **Miscellaneous Areas.** Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations such as driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. The specified layer thickness is based on the rate of 90 lb. per square yard for each inch of pavement unless another rate is shown on the plans. Miscellaneous areas are not subject to thermal profiles testing.

4.9.8. **Recovered Asphalt Dynamic Shear Rheometer (DSR).** The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Materials and Tests Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with Tex-211-F.

4.9.9. **Irregularities.** Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) areas where the mixture does not bond to the existing pavement.

If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.10. **Exempt Production.** When the anticipated daily production is less than 100 ton, all QC and QA sampling and testing are waived. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is more than 100 ton but less than 250 ton;
- total production for the project is less than 2,500 ton;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements. All other specification requirements apply, and the Engineer will perform acceptance tests for production and placement in accordance with Table 13.
For exempt production:

- produce, haul, place, and compact the mixture as directed by the Engineer; and
- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target density as tested by the Engineer.

4.9.11. **Ride Quality**. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

5.1. **PFC Hot-Mix Asphalt.** Permeable friction course (PFC) hot-mix will be measured by the ton of composite mixture, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.2. **TBFC Hot-Mix Asphalt.** Thin bonded friction course (TBFC) hot-mix will be measured by the ton of composite mixture, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.3. **Membrane.** Membrane material will be measured by volume. Membrane material will be measured at the applied temperature by strapping the tank before and after road application and determining the net volume in gallons from the distributor's calibrated strap stick. The Engineer will witness all operations for volume determination. All membrane will be measured by the gallon applied, in the accepted membrane.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3082.5.1., "PFC Hot-Mix Asphalt," will be paid for at the unit bid price for "Permeable friction course" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, removing pavement marking and markers, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3082.5.2., "TBFC Hot-Mix Asphalt," will be paid for at the unit bid price for "Thin bonded friction course" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, removing pavement marking and markers, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Section 3082.5.3., "Membrane," will be paid for at the unit bid price for "Membrane" of the membrane material provided. These prices are full compensation for materials, placement, equipment, labor, tools, and incidentals.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

Special Specification 3096
Asphalts, Oils, and Emulsions

1. DESCRIPTION

Provide asphalt cements, cutback and emulsified asphalts, performance-graded asphalt binders, and other miscellaneous asphalt materials as specified on the plans.

2. MATERIALS

Provide asphalt materials that meet the stated requirements when tested in conformance with the referenced Department, AASHTO, and ASTM test methods. Use asphalt containing recycled materials only if the recycled components meet the requirements of Article 6.9., "Recycled Materials." Provide asphalt materials that the Department has preapproved for use in accordance with Tex-545-C, "Asphalt Binder Quality Program."

Inform the Department of all additives or modifiers included in the asphalt binder as part of the facility quality plan, as required by Tex-545-C, "Asphalt Binder Quality Program," and provide that information to Department personnel. The Department reserves the right to prohibit the use of any asphalt additive or modifier.

Limit the use of polyphosphoric acid to no more than 0.5% by weight of the asphalt binder.

The use of re-refined engine oil bottoms is prohibited.

Acronyms used in this Item are defined in Table 1.

Table1
Acronyms

Acronym	Definition
Test Procedure Designations	
Tex	Department
T or R	AASHTO
D	ASTM
Polymer Modifier Designations	
P	polymer-modified
SBR or L	styrene-butadiene rubber (latex)
SBS	styrene-butadiene-styrene block co-polymer
TR	tire rubber (from ambient temperature grinding of truck and passenger tires)
AC	asphalt cement
AE	asphalt emulsion
AE-P	asphalt emulsion prime
A-R	asphalt-rubber
C	cationic
EAP&T	emulsified asphalt prime and tack
EBL	emulsified bonding layer
FDR	full depth reclamation
H-suffix	harder residue (lower penetration)
HF	high float
HY	high yield
MC	medium-curing
MS	medium-setting
PCE	prime, cure, and erosion control
PG	performance grade
RC	rapid-curing
RS	rapid-setting
S-suffix	stockpile usage
SCM	special cutback material
SS	slow-setting
SY	standard yield
TRAIL	tracking resistant asphalt interlayer

2.1. **Asphalt Cement**. Provide asphalt cement that is homogeneous, water-free, and nonfoaming when heated to 347°F, and meets the requirements in Table 2.

Table 2
Asphalt Cement

Property	Test Procedure	Viscosity Grade									
		AC-0.6		AC-1.5		AC-3		AC-5		AC-10	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity	T 202										
140°F, poise		40	80	100	200	250	350	400	600	800	1,200
275°F, poise		0.4	–	0.7	–	1.1	–	1.4	–	1.9	–
Penetration, 77°F, 100g, 5 sec.	T 49	350	–	250	–	210	–	135	–	85	–
Flash point, C.O.C., °F	T 48	425	–	425	–	425	–	425	–	450	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.		Neg.		Neg.	
Tests on residue from RTFOT:	T 240										
Viscosity, 140°F, poise	T 202	–	180	–	450	–	900	–	1,500	–	3,000
Ductility,[1] 77°F 5 cm/min., cm	T 51	100	–	100	–	100	–	100	–	100	–

1. If AC-0.6 or AC-1.5 ductility at 77°F is less than 100 cm, material is acceptable if ductility at 60°F is more than 100 cm.

2.2. **Polymer-Modified Asphalt Cement**. Provide polymer-modified asphalt cement that is smooth, homogeneous, and meets the requirements Table 3. Supply samples of the base asphalt cement and polymer additives if requested.

Table 3
Polymer-Modified Asphalt Cement

Property	Test Procedure	Polymer-Modified Viscosity Grade											
		AC-12-5TR		NT-HA[1]		AC-15P		AC-20XP		AC-10-2TR		AC-20-5TR	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Polymer		TR		–		SBS		SBS		TR		TR	
Polymer content, % (solids basis)	Tex-533-C or Tex-553-C	5.0	–	–	–	3.0	–	–	–	2.0	–	5.0	–
Dynamic shear, G*/sinδ, 82°C, 10 rad/s, kPa	T 315			1.0	–								
Dynamic shear, G*/sinδ, 64°C, 10 rad/s, kPa	T 315	–	–	–	–	–	–	1.0	–	–	–	1.0	–
Dynamic shear, G*/sinδ, 58°C, 10 rad/s, kPa	T 315	1.0	–	–	–	–	–	–	–	1.0	–	–	–
Viscosity 140°F, poise 275°F, poise	 T 202 T 202	 1,200	 –	 –	 4,000	 1,500 –	 – 8.0	 2,000 –	 – –	 1,000 –	 – 8.0	 2,000 –	 – 10.0
Penetration, 77°F, 100 g, 5 sec.	T 49	110	150	–	25	100	150	75	115	95	130	75	115
Ductility, 5cm/min., 39.2°F, cm	T 51					–	–	–	–	–	–	–	–
Elastic recovery, 50°F, %	Tex-539-C	55	–			55	–	55	–	30	–	55	–
Softening point, °F	T 53	113	–	170	–	–	–	120	–	110	–	120	–
Polymer separation, 5 hr.	Tex-540-C	None				None		None		None		None	
Flash point, C.O.C., °F	T 48	425	–	425	–	425	–	425	–	425	–	425	–
Tests on residue from RTFOT aging and pressure aging:	T 240 and R 28												
Creep stiffness S, -18°C, MPa m-value, -18°C	T 313	 – 0.300	 300 –	 – –	 – –	 – 0.300	 300 –	 – 0.300	 300 –	 – 0.300	 300 –	 – 0.300	 300 –

1. Non-Tracking Hot Applied Tack Coat - TRAIL product

2.3. **Cutback Asphalt**. Provide cutback asphalt that meets the requirements of Tables 4, 5, and 6, for the specified type and grade. Supply samples of the base asphalt cement and polymer additives if requested.

Table 4
Rapid-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade					
		RC-250		RC-800		RC-3000	
		Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	250	400	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	80	–	80	–	80	–
Distillation test:	T 78						
Distillate, percentage by volume of total distillate to 680°F							
to 437°F		40	75	35	70	20	55
to 500°F		65	90	55	85	45	75
to 600°F		85	–	80	–	70	–
Residue from distillation, volume %		70	–	75	–	82	–
Tests on distillation residue:							
Viscosity, 140°F, poise	T 202	600	2,400	600	2,400	600	2,400
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.	

Table 5
Medium-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade							
		MC-30		MC-250		MC-800		MC-3000	
		Min	Max	Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	30	60	250	500	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	95	–	122	–	140	–	149	–
Distillation test:	T 78								
Distillate, percentage by volume of total distillate to 680°F									
to 437°F		–	35	–	20	–	–	–	–
to 500°F		30	75	5	55	–	40	–	15
to 600°F		75	95	60	90	45	85	15	75
Residue from distillation, volume %		50	–	67	–	75	–	80	–
Tests on distillation residue:									
Viscosity, 140°F, poise	T 202	300	1,200	300	1,200	300	1,200	300	1,200
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.		Neg.	

Table 6
Special-Use Cutback Asphalt

Property	Test Procedure	Type–Grade					
		MC-2400L		SCM I		SCM II	
		Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	2,400	4,800	500	1,000	1,000	2,000
Water, %	D95	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	150	–	175	–	175	–
Distillation test:	T 78						
Distillate, percentage by volume of total distillate to 680°F							
to 437°F		–	–	–	–	–	–
to 500°F		–	35	–	0.5	–	0.5
to 600°F		35	80	20	60	15	50
Residue from distillation, volume %		78	–	76	–	82	–
Tests on distillation residue:							
Polymer		SBR		–		–	
Polymer content, % (solids basis)	Tex-533-C	2.0	–	–	–	–	–
Penetration, 100 g, 5 sec., 77°F	T 49	150	300	180	–	180	–
Ductility, 5 cm/min., 39.2°F, cm	T 51	50	–	–	–	–	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–

2.4. **Emulsified Asphalt**. Provide emulsified asphalt that is homogeneous, does not separate after thorough mixing, and meets the requirements for the specified type and grade in Tables 7, 8, 9, 10, and 10A-C.

Table 7
Emulsified Asphalt

Property	Test Procedure	Type–Grade									
		Rapid-Setting		Medium-Setting				Slow-Setting			
		HFRS-2		MS-2		AES-300		SS-1		SS-1H	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72										
77°F, sec.		–	–	–	–	75	400	20	100	20	100
122°F, sec.		150	400	100	300	–	–	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Miscibility	T 59	–		–		–		Pass		Pass	
Cement mixing, %	T 59	–	–	–	–	–	–	–	2.0	–	2.0
Coating ability and water resistance:	T 59										
Dry aggregate/after spray		–		–		Good/Fair		–		–	
Wet aggregate/after spray		–		–		Fair/Fair		–		–	
Demulsibility, 35 mL of 0.02 N $CaCl_2$, %	T 59	50	–	–	30	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1
Freezing test, 3 cycles[1]	T 59	–		Pass		–		Pass		Pass	
Distillation test:	T 59										
Residue by distillation, % by wt.		65	–	65	–	65	–	60	–	60	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	5	–	0.5	–	0.5
Tests on residue from distillation:											
Penetration, 77°F, 100 g, 5 sec.	T 49	100	140	120	160	300	–	120	160	70	100
Solubility in trichloroethylene, %	T 44	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–
Ductility, 77°F, 5 cm/min., cm	T 51	100	–	100	–	–	–	100	–	80	–
Float test, 140°F, sec.	T 50	1,200	–	–	–	1,200	–	–	–	–	–

1. Applies only when the Engineer designates material for winter use.

Table 8
Cationic Emulsified Asphalt

Property	Test Procedure	Type–Grade											
		Rapid-Setting				Medium-Setting				Slow-Setting			
		CRS-2		CRS-2H		CMS-2		CMS-2S		CSS-1		CSS-1H	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72												
77°F, sec.		–	–	–	–	–	–	–	–	20	100	20	100
122°F, sec.		150	400	150	400	100	300	100	300	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Cement mixing, %	T 59	–	–	–	–	–	–	–	–	–	2.0	–	2.0
Coating ability and water resistance:	T 59												
Dry aggregate/after spray		–		–		Good/Fair		Good/Fair		–		–	
Wet aggregate/after spray		–		–		Fair/Fair		Fair/Fair		–		–	
Demulsibility, 35 mL of 0.8% Sodium dioctyl sulfosuccinate, %	T 59	70	–	70	–	–	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1	–	1
Particle charge	T 59	Positive		Positive		Positive		Positive		Positive		Positive	
Distillation test:													
Residue by distillation, % by wt.	T 59	65	–	65	–	65	–	65	–	60	–	60	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	7	–	5	–	0.5	–	0.5
Tests on residue from distillation:													
Penetration, 77°F, 100 g, 5 sec.	T 49	120	160	70	110	120	200	300	–	120	160	70	110
Solubility in trichloroethylene, %	T 44	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–
Ductility, 77°F, 5 cm/min., cm	T 51	100	–	80	–	100	–		–	100	–	80	–

Table 9
Polymer-Modified Emulsified Asphalt

Property	Test Procedure	Type–Grade									
		Rapid-Setting		Medium-Setting				Slow-Setting			
		HFRS-2P		AES-150P		AES-300P		AES-300S		SS-1P	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72										
77°F, sec.		–	–	75	400	75	400	75	400	30	100
122°F, sec.		150	400					–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Miscibility	T 59	–		–		–		–		Pass	
Coating ability and water resistance:											
Dry aggregate/after spray	T 59	–		Good/Fair		Good/Fair		Good/Fair		–	
Wet aggregate/after spray		–		Fair/Fair		Fair/Fair		Fair/Fair		–	
Demulsibility, 35 mL of 0.02 N $CaCl_2$, %	T 59	50	–	–	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1
Breaking index, g	Tex-542-C	–	–								
Distillation test:[1]	T 59										
Residue by distillation, % by wt.		65	–	65	–	65	–	65	–	60	–
Oil distillate, % by volume of emulsion		–	0.5	–	3	–	5	–	7	–	0.5
Tests on residue from distillation:											
Polymer content, wt. % (solids basis)	Tex-533-C	3.0	–	–	–	–	–	–	–	3.0	–
Penetration, 77°F, 100 g, 5 sec.	T 49	90	140	150	300	300	–	300	–	100	140
Solubility in trichloroethylene, %	T 44	97.0	–	97.0	–	97.0	–	97.0	–	97.0	–
Viscosity, 140°F, poise	T 202	1,500	–	–	–	–	–	–	–	1,300	–
Float test, 140°F, sec	T 50	1,200	–	1,200	–	1,200	–	1,200	–	–	–
Ductility,[2] 39.2°F, 5 cm/min., cm	T 51	50	–	–	–	–	–	–	–	50	–
Elastic recovery,2 50°F, %	Tex-539-C	55	–	–	–	–	–	–	–	–	–
Tests on RTFO curing of distillation residue	T 240										
Elastic recovery, 50°F, %	Tex-536-C	–	–	50	–	50	–	30	–	–	–

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F ±10°F. Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. HFRS-2P must meet one of either the ductility or elastic recovery requirements.

Table 10
Polymer-Modified Cationic Emulsified Asphalt

Property	Test Procedure	Type–Grade											
		Rapid-Setting						Medium-Setting				Slow-Setting	
		CRS-2P		CHFRS-2P		CRS-2TR		CMS-1P[3]		CMS-2P[3]		CSS 1P	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72												
77°F, sec.		–	–	–	–	–	–	10	100	–	–	20	100
122°F, sec.		150	400	100	400	150	500	–	–	50	400	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Demulsibility, 35 ml of 0.8% sodium dioctyl sulfosuccinate, %	T 59	70	–	60	–	40	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1	–	1
Breaking index, g	Tex-542-C	–	–	–	–	–	–	–	–	–	–	–	–
Particle charge	T 59	Positive		Positive		Positive		Positive		Positive		Positive	
Distillation test[1]:	T 59												
Residue by distillation, % by weight		65	–	65	–	65	–	30	–	60	–	62	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	3	–	0.5	–	0.5	–	0.5
Tests on residue from distillation:													
Polymer content, wt. % (solids basis)	Tex-533-C	3.0	–	3.0	–	5.0[7]	–	–	–	–	–	3.0	–
Penetration, 77°F, 100 g, 5 sec.	T 49	90	150	80	130	90	150	30	–	30	–	55	90
Viscosity, 140°F, poise	T 202	1,300	–	1,300	–	1,000	–	–	–	–	–	–	–
Solubility in trichloroethylene, %	T44	97.0	–	95.0	–	98	–	–	–	–	–	97.0	–
Softening point, °F	T 53	–	–	–	–	–	–	–	–	–	–	135	–
Ductility, 77°F, 5 cm/min., cm	T 51	–	–	–	–	40	–	–	–	–	–	70	–
Float test, 140°F, sec.	T 50	–	–	1,800	–	–	–	–	–	–	–	–	–
Ductility,[2] 39.2°F, 5 cm/min., cm	T 51	50	–	–	–	–	–	–	–	–	–	–	–
Elastic recovery,[2] 50°F, %	Tex-539-C	55	–	55	–	–	–	–	–	–	–	–	–
Tests on residue from evaporative recovery:	R 78, Procedure B												
Nonrecoverable creep compliance of residue, 3.2 kPa, 52°C, kPa-[1]	T 350	–	–	–	–	–	–	–	2.0	–	4.0	–	–
Tests on rejuvenating agent:													
Viscosity, 140°F, cSt	T 201	–	–	–	–	–	–	50	175	50	175	–	–
Flash point, C.O.C., °F	T 48	–	–	–	–	–	–	380	–	380	–	–	–
Saturates, % by weight	D 2007	–	–	–	–	–	–	–	30	–	30	–	–
Solubility in n-pentane, % by weight	D 2007	–	–	–	–	–	–	99	–	99	–	–	–
Tests on rejuvenating agent after RTFO	T 240												
Weight Change, %		–	–	–	–	–	–	–	6.5	–	6.5	–	–
Viscosity Ratio		–	–	–	–	–	–	–	3.0	–	3.0	–	–
Tests on latex[4]:													
Tensile strength, die C dumbbell, psi	D 412[5]	–	–	–	–	–	–	800	–	800	–	–	–
Change in mass after immersion in rejuvenating agent, %	D 471	–	–	–	–	–	–	–	40[6]	–	40[6]	–	–

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F (±0°F). Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. CRS-2P must meet one of either the ductility or elastic recovery requirements.
3. With all precertification samples of CMS-1P or CMS-2P, submit certified test reports showing that the rejuvenating agent and latex meet the stated requirements. Submit samples of these raw materials if requested by the Engineer.
4. Preparation of latex specimens: use any substrate and recovery method which produces specimens of uniform dimensions and which delivers enough material to achieve desired residual thickness.
5. Cut samples for tensile strength determination using a crosshead speed of 20 in. per minute.
6. Specimen must remain intact after exposure and removal of excess rejuvenating agent.
7. Modifier type is tire rubber.

Table 10A
Non-Tracking Tack Coat Emulsion[1]

Property	Test Procedure	NT-HRE		NT-RRE		NT-SRE	
		Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol 77º F, sec.	T 72	15	–	15	–	10	100
Storage stability, 1 Day, %	T 59	–	1	–	1	–	1
Settlement, 5-day, %	T 59	–	5	–	5	–	5
Sieve test, %	T 59	–	0.30	–	0.30	–	0.1
Distillation test:[2]	T 59						
Residue by distillation, % by wt.		50	–	58	–	50	–
Oil distillate, by volume of emulsion		–	1.0	–	1.0	–	1.0
Test on residue from distillation:							
Penetration, 77ºF, 100 g, 5 sec.	T 49	–	20	15	45	40	90
Solubility in trichloroethylene, %	T 44	97.5	–	97.5	–	97.5	–
Softening point, ºF	T 53	150	–	–	–	–	–
Dynamic shear, G*/sin(δ), 82°C, 10 rad/s, kPa	T 315	1.0	–	–	–	–	–

1. Due to the hardness of the residue, these emulsions should be heated to 120-140°F before thoroughly mixing as the emulsion is being prepared for testing.
2. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350ºF ± 10ºF. Maintain at this temperature for 20 min. Complete total distillation in 60 ± 5 min. from first application of heat.

Table10B
Spray Applied Underseal Membrane Polymer-Modified Emulsions (EBL)

Property	Test Procedure	Min	Max
Viscosity @ 77°F, SSF	T 72	20	100
Storage Stability[1], %	T 59	–	1
Demulsibility[2] Anionic emulsions – 35 mL of 0.02 N CaCl2, % Cationic emulsions – 35 mL of 0.8% sodium dioctyl sulfosuccinate, %	T 59	55	–
Sieve Test[3], %	T 59	–	0.05
Distillation Test[4]	T 59		
Residue by distillation, % by wt.		63	
Oil portion of distillate, % by vol.			0.5
Test on Residue from Distillation			
Elastic Recovery @ 50°F, 50 mm/min., %	Tex-539-C	60	–
Penetration @ 77°F, 100 g, 5 sec., 0.1 mm	T 49	80	130

1. After standing undisturbed for 24 hr., the surface must be smooth, must not exhibit a white or milky colored substance, and must be a homogeneous color throughout.
2. Material must meet demulsibility test for emulsions.
3. May be required by the Engineer only when the emulsion cannot be easily applied in the field.
4. The temperature on the lower thermometer should be brought slowly to 350°F ± 10°F and maintained at this temperature for 20 min. The total distillation should be completed in 60 ± 5 min. from the first application of heat.

Table 10C
Full-Depth Reclamation Emulsion (FDR EM)

Property	Test Procedure	Standard Yield (SY)		High Yield (HY)	
		Min	Max	Min	Max
Sieve test, %	T 59	–	0.1	–	0.1
Viscosity Saybolt Furol @ 77°F, sec.	T 59	20	100	20	100
Distillation test[1]:	T 59				
Residue by distillation, % by wt.		60	–	63	–
Oil portion of distillate, % by vol.		–	0.5	–	0.5
Test on residue from distillation:	T 49				
Penetration @ 77°F, dmm		55	95	120	–
Test on rejuvenating agent:					
BWOA, %[2]	***	–	–	2	–
Viscosity @ 140°F, cSt	T 201	–	–	50	175
Flash Point, COC, °F	T 48	–	–	380	–
Solubility in n-pentane, % by wt.	D2007	–	–	99	–

1. The temperature on the lower thermometer should be brought slowly to 350°F ±10°F and maintained at this temperature for 20 min. The total distillation should be completed in 60 ± 5 min. from the first application of heat.
2. BWOA = By weight of asphalt. Provide a manufacturer's certificate of analysis (COA) with the percent of rejuvenator added.

2.5. **Specialty Emulsions.** Provide specialty emulsion that is either asphalt-based or resin-based and meets the requirements of Table 11 or Table 11A.

Table 11
Specialty Emulsions

Property	Test Procedure	Type–Grade					
		Medium-Setting				Slow-Setting	
		AE-P		EAP&T		PCE[1]	
		Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72						
77°F, sec.		–	–	–	–	10	100
122°F, sec.		15	150	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1
Miscibility[2]	T 59	–		Pass		Pass	
Demulsibility, 35 mL of 0.10 N $CaCl^2$, %	T 59	–	70	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	–
Particle size,[5] % by volume < 2.5 μm	Tex-238-F[3]	–	–	90	–	90	–
Asphalt emulsion distillation to 500°F followed by Cutback asphalt distillation of residue to 680°F:	T 59 & T 78						
Residue after both distillations, % by wt.		40	–	–	–	–	–
Total oil distillate from both distillations, % by volume of emulsion		25	40	–	–	–	–
Residue by distillation, % by wt.	T 59	–	–	60	–	–	–
Residue by evaporation,[4] % by wt.	T 59	–	–	–	–	60	–
Tests on residue after all distillations:							
Viscosity, 140°F, poise	T 202	–	–	800	–	–	–
Kinematic viscosity,[5] 140°F, cSt	T 201	–	–	–	–	100	350
Flash point C.O.C., °F	T 48	–	–	–	–	400	–
Solubility in trichloroethylene, %	T 44	97.5	–	–	–	–	–
Float test, 122°F, sec.	T 50	50	200	–	–	–	–

1. Supply with each shipment of PCE:
   - a copy of a lab report from an approved analytical lab, signed by a lab official, indicating the PCE formulation does not meet any characteristics of a Resource Conservation Recovery Act (RCRA) hazardous waste;
   - a certification from the producer that the formulation supplied does not differ from the one tested and that no listed RCRA hazardous wastes or Polychlorinated Biphenyls (PCBs) have been mixed with the product; and
   - a Safety Data Sheet.
2. Exception to T 59: In dilution, use 350 mL of distilled or deionized water and a 1,000-mL beaker.
3. Use Tex-238-F, beginning at "Particle Size Analysis by Laser Diffraction," with distilled or deionized water as a medium and no dispersant, or use another approved method.
4. Exception to T 59: Leave sample in the oven until foaming ceases, then cool and weigh.
5. PCE must meet either the kinematic viscosity requirement or the particle size requirement.

Table 11A
Hard Residue Surface Sealant

Property	Test Procedure	Min	Max
Viscosity, Krebs unit, 77ºF, Krebs units	D 562	45	75
Softening point, ºF	Tex-505-C[1]	250	–
Uniformity	D 2939	Pass[2]	
Resistance to heat	D 2939	Pass[3]	
Resistance to water	D 2939	Pass[4]	
Wet flow, mm	D 2939	–	0
Resistance to Kerosene (optional)[5]	D 2939	Pass[6]	
Ultraviolet exposure, UVA-340, 0.77 W/m^2, 50°C chamber, 8 hr. UV lamp, 5 min. spray, 3 hr. 55 min. condensation, 1,000 hr. total exposure[7]	G 154	Pass[8]	
Abrasion loss, 1.6 mm thickness, liquid only, %	ISSA TB-100	–	1.0
Residue by evaporation, % by weight	D 2939	33	–
Tests on residue from evaporation: Penetration, 77ºF, 100 g, 5 sec. Flash point, Cleveland open cup, °F	 T 49 T 48	 15 500	 30
Tests on base asphalt before emulsification Solubility in trichloroethylene, %	 T 44	 98	 –

1. Cure the emulsion in the softening point ring in a 200°F ± 5°F oven for 2 hr.
2. Product must be homogenous and show no separation or coagulation that cannot be overcome by moderate stirring.
3. No sagging or slippage of film beyond the initial reference line.
4. No blistering or re-emulsification.
5. Recommended for airport applications or where fuel resistance is desired.
6. No absorption of Kerosene into the clay tile past the sealer film. Note sealer surface condition and loss of adhesion.
7. Other exposure cycles with similar levels of irradiation and conditions may be used with Department approval.
8. No cracking, chipping, surface distortion, or loss of adhesion. No color fading or lightening.

2.6. **Recycling Agent**. Recycling agent and emulsified recycling agent must meet the requirements in Table 12. Additionally, recycling agent and residue from emulsified recycling agent, when added in the specified proportions to the recycled asphalt, must meet the properties specified on the plans.

Table 12
Recycling Agent and Emulsified Recycling Agent

Property	Test Procedure	Recycling Agent		Emulsified Recycling Agent (ARA-1)		Polymer Modified Emulsified Recycling Agent (ARA-1P)	
		Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol, 77°F, sec.	T 72	–	–	15	100	15	110
Sieve test, %	T 59	–	–	–	0.1	–	0.1
Miscibility[1]	T 59	–		No coagulation			
Residue by evaporation,[2] % by wt.	T 59	–	–	60	–	–	–
Distillation test: Residue by distillation, % by wt. Oil distillate, % by volume of emulsion	T 59					 60 –	 65 2
Penetration of Distillation Residue at 39.2°F, 100 g, 5 sec.	T 49					110	190
Tests on recycling agent or residue from evaporation: Flash point, C.O.C., °F Kinematic viscosity, 140°F, cSt 275°F, cSt	 T 48 T 201	 400 75 –	 – 200 10.0	 400 75 –	 – 200 10.0	 400	 –

1. Exception to T 59: Use 0.02 N CaCl2 solution in place of water.
2. Exception to T 59: Maintain sample at 300°F until foaming ceases, then cool and weigh.

2.7. **Crumb Rubber Modifier**. Crumb rubber modifier (CRM) consists of automobile and truck tires processed by ambient temperature grinding.

CRM must be:

- free from contaminants including fabric, metal, and mineral and other nonrubber substances;
- free-flowing; and
- nonfoaming when added to hot asphalt binder.

Ensure rubber gradation meets the requirements of the grades in Table 13 when tested in accordance with Tex-200-F, Part I, using a 50-g sample.

Table 13
CRM Gradations

Sieve Size (% Passing)	Grade A		Grade B		Grade C		Grade D	Grade E
	Min	Max	Min	Max	Min	Max		
#8	100	–	–	–	–	–	As shown on the plans	As approved
#10	95	100	100	–	–	–		
#16	–	–	70	100	100	–		
#30	–	–	25	60	90	100		
#40	–	–	–	–	45	100		
#50	0	10	–	–	–	–		
#200	–	–	0	5	–	–		

2.8. **Crack Sealer**. Provide polymer-modified asphalt-emulsion crack sealer meeting the requirements of Table 14. Provide rubber-asphalt crack sealer meeting the requirements of Table 15.

Table 14
Polymer-Modified Asphalt-Emulsion Crack Sealer

Property	Test Procedure	Min	Max
Rotational viscosity, 77°F, cP	D 2196, Method A	10,000	25,000
Sieve test, %	T 59	–	0.1
Storage stability, 1 day, %	T 59	–	1
Evaporation Residue by evaporation, % by wt.	Tex-543-C	65	–
Tests on residue from evaporation: Penetration, 77°F, 100 g, 5 sec. Softening point, °F Ductility, 39.2°F, 5 cm/min., cm	 T 49 T 53 T 51	 35 140 100	 75 – –

Table 15
Rubber-Asphalt Crack Sealer

Property	Test Procedure	Class A		Class B	
		Min	Max	Min	Max
CRM content, Grade A or B, % by wt.	Tex-544-C	22	26	–	–
CRM content, Grade B, % by wt.	Tex-544-C	–	–	13	17
Virgin rubber content,[1] % by wt.		–	–	2	–
Flash point,[2] C.O.C., °F	T 48	400	–	400	–
Penetration,[3] 77°F, 150 g, 5 sec.	T 49	30	50	30	50
Penetration,[3] 32°F, 200 g, 60 sec.	T 49	12	–	12	–
Softening point, °F	T 53	–	–	170	–
Bond Test, non-immersed, 0.5 in specimen, 50% extension, 20°F[4]	D5329	–		Pass	

1. Provide certification that the Min % virgin rubber was added.
2. Agitate the sealing compound with a 3/8- to 1/2 in. (9.5- to 12.7 mm) wide, square-end metal spatula to bring the material on the bottom of the cup to the surface (i.e., turn the material over) before passing the test flame over the cup. Start at one side of the thermometer, move around to the other, and then return to the starting point using 8 to 10 rapid circular strokes. Accomplish agitation in 3 to 4 sec. Pass the test flame over the cup immediately after stirring is completed.
3. Exception to T 49: Substitute the cone specified in D 217 for the penetration needle.
4. Allow no crack in the crack sealing materials or break in the bond between the sealer and the mortar blocks over 1/4 in. deep for any specimen after completion of the test.

2.9. **Asphalt-Rubber Binders**. Provide asphalt-rubber (A-R) binders that are mixtures of asphalt binder and CRM, which have been reacted at elevated temperatures. Provide A-R binders meeting D6114 and containing a minimum of 15% CRM by weight. Provide Types I or II, containing CRM Grade C, for use in hot-mixed aggregate mixtures. Provide Types II or III, containing CRM Grade B, for use in surface treatment binder. Ensure binder properties meet the requirements of Table 16.

Table 16
A-R Binders

Property	Test Procedure	Binder Type					
		Type I		Type II		Type III	
		Min	Max	Min	Max	Min	Max
Apparent viscosity, 347°F, cP	D2196, Method A	1,500	5,000	1,500	5,000	1,500	5,000
Penetration, 77°F, 100 g, 5 sec.	T 49	25	75	25	75	50	100
Penetration, 39.2°F, 200 g, 60 sec.	T 49	10	–	15	–	25	–
Softening point, °F	T 53	135	–	130	–	125	–
Resilience, 77°F, %	D5329	25	–	20	–	10	–
Flash point, C.O.C., °F	T 48	450	–	450	–	450	–
Tests on residue from Thin-Film Oven Test: Retained penetration ratio, 39.2°F, 200 g, 60 sec., % of original	T 179 T 49	75	–	75	–	75	–

2.10. **Performance-Graded Binders**. Provide PG binders that are smooth and homogeneous, show no separation when tested in accordance with Tex-540-C, and meet the requirements of Table 17.

Separation testing is not required if:

- a modifier is introduced separately at the mix plant either by injection in the asphalt line or mixer,
- the binder is blended on site in continuously agitated tanks, or
- binder acceptance is based on field samples taken from an in-line sampling port at the hot-mix plant after the addition of modifiers.

Table 17
Performance-Graded Binders

Property and Test Method	Performance Grade																		
	PG 58			PG 64				PG 70				PG 76				PG 82			
	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	
Average 7-day max pavement design temperature, °C[1]	58			64				70				76				82			
Min pavement design temperature, °C[1]	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	
Original Binder																			
Flash point, T 48, Min, °C	230																		
Viscosity, T 316[2, 3]: Max, 3.0 Pa·s, test temperature, °C	135																		
Dynamic shear, T 315[4]: G*/sin(δ), Min, 1.00 kPa, Max, 2.00 kPa[7], Test temperature @ 10 rad/sec., °C	58			64				70				76				82			
Elastic recovery, D6084, 50°F, % Min[8]	–	–	30	–	–	30	50	–	30	50	60	30	50	60	70	50	60	70	
Rolling Thin-Film Oven (Tex-506-C)																			
Mass change, T 240, Max, %	1.0																		
Dynamic shear, T 315: G*/sin(δ), Min, 2.20 kPa, Max, 5.00 kPa[7], Test temperature @ 10 rad/sec., °C	58			64				70				76				82			
MSCR, T350, Recovery, 0.1 kPa, High Temperature, % Min[8]	–	–	20	–	–	20	30	–	20	30	40	20	30	40	50	30	40	50	
Pressure Aging Vessel (PAV) Residue (R 28)																			
PAV aging temperature, °C	100																		
Dynamic shear, T 315: G*sin(δ), Max, 5,000 kPa Test temperature @ 10 rad/sec., °C	25	22	19	28	25	22	19	28	25	22	19	28	25	22	19	28	25	22	
Creep stiffness, T 313[5, 6]: *S*, max, 300 MPa, *m*-value, Min, 0.300 Test temperature @ 60 sec., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	
Direct tension, T 314[6]: Failure strain, min, 1.0% Test temperature @ 1.0 mm/min., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	

1. Pavement temperatures are estimated from air temperatures and using an algorithm contained in a Department-supplied computer program, may be provided by the Department, or by following the procedures outlined in AASHTO MP 2 and PP 28.
2. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. At test temperatures where the binder is a Newtonian fluid, any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
3. Viscosity at 135°C is an indicator of mixing and compaction temperatures that can be expected in the lab and field. High values may indicate high mixing and compaction temperatures. Additionally, significant variation can occur from batch to batch. Contractors should be aware that variation could significantly impact their mixing and compaction operations. Contractors are therefore responsible for addressing any constructability issues that may arise.
4. For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be substituted for dynamic shear measurements of G*/sin(δ) at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
5. Silicone beam molds, as described in AASHTO TP 1-93, are acceptable for use.
6. If creep stiffness is below 300 MPa, direct tension test is not required. If creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m value requirement must be satisfied in both cases.
7. Maximum values for unaged and RTFO aged dynamic shear apply only to materials used as substitute binders, as described in Item 340, "Dense-Graded Hot-Mix Asphalt (Small Quantity)", Item 341, "Dense-Graded Hot-Mix Asphalt, and Item 344, "Superpave Mixtures."
8. Elastic Recovery (ASTM D6084) is not required unless MSCR (AASHTO T 350) is less than the minimum % recovery. Elastic Recovery must be used for the acceptance criteria in this instance.

3. EQUIPMENT

Provide all equipment necessary to transport, store, sample, heat, apply, and incorporate asphalts, oils, and emulsions.

4. CONSTRUCTION

Typical Material Use. Use materials shown in Table 18, unless otherwise determined by the Engineer.

Table18
Typical Material Use

Material Application	Typically Used Materials
Hot-mixed, hot-laid asphalt mixtures	PG binders, A-R binders Types I and II
Surface treatment	AC-5, AC-10, AC-15P, AC-20XP, AC-10-2TR, AC-20-5TR, HFRS-2, MS-2, CRS-2, CRS-2H, CRS-2TR, CMS-2P HFRS-2P, CRS-2P, CHFRS-2P, A-R binders Types II and III
Surface treatment (cool weather)	AC12-5TR, RC-250, RC-800, RC-3000, MC-250, MC-800, MC-3000, MC-2400L, CMS-2P
Precoating	AC-5, AC-10, PG 64-22, SS-1, SS-1H, CSS-1, CSS-1H
Tack coat	PG Binders, SS-1H, CSS-1H, EAP&T, TRAIL, EBL
Fog seal	SS-1, SS-1H, CSS-1, CSS-1H, CMS-1P
Hot-mixed, cold-laid asphalt mixtures	AC-0.6, AC-1.5, AC-3, AES-300, AES-300P, CMS-2, CMS-2S
Patching mix	MC-800, SCM I, SCM II, AES-300S
Recycling	AC-0.6, AC-1.5, AC-3, AES-150P, AES-300P, recycling agent, emulsified recycling agent
Crack sealing	SS-1P, polymer mod AE crack sealant, rubber asphalt crack sealers (Class A, Class B)
Microsurfacing	CSS-1P
Prime	MC-30, AE-P, EAP&T, PCE
Curing membrane	SS-1, SS-1H, CSS-1, CSS-1H, PCE
Erosion control	SS-1, SS-1H, CSS-1, CSS-1H, PCE
FDR -Foaming	PG 64-22, FDR EM-SY, FDR EM-HY

4.1. **Storage and Application Temperatures**. Use storage and application temperatures in accordance with Table 19. Store and apply materials at the lowest temperature yielding satisfactory results. Follow the manufacturer's instructions for any agitation requirements in storage. Manufacturer's instructions regarding recommended application and storage temperatures supersede those of Table 19.

Table19
Storage and Application Temperatures

Type-Grade	Application		Storage Max (°F)
	Recommended Range (°F)	Max Allowable (°F)	
AC-0.6, AC-1.5, AC-3	200–300	350	350
AC-5, AC-10	275–350	350	350
AC-15P, AC-20-5TR, AC12-5TR and AC10-2TR	300–375	375	360
RC-250	125–180	200	200
RC-800	170–230	260	260
RC-3000	215–275	285	285
MC-30, AE-P	70–150	175	175
MC-250	125–210	240	240
MC-800, SCM I, SCM II	175–260	275	275
MC-3000, MC-2400L	225–275	290	290
HFRS-2, MS-2, CRS-2, CRS-2H, HFRS-2P, CRS-2P, CMS-2, CMS-2S, AES-300, AES-300S, AES-150P, AES-300P, CRS-2TR	120–160	180	180
SS-1, SS-1H, CSS-1, CSS-1H, PCE, EAP&T, SS-1P, RS-1P, CRS-1P, CSS-1P, recycling agent, emulsified recycling agent, polymer mod AE crack sealant	50–130	140	140
PG binders	275–350	350	350
Rubber asphalt crack sealers (Class A, Class B)	350–375	400	–
A-R binders Types I, II, and III	325–425	425	425

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but is subsidiary or is included in payment for other pertinent Items.

Special Specification 4008
Trench Drain

1. DESCRIPTION

Construct cast in place surface drainage trench.

2. MATERIALS

Provide a trench with a slope as shown on the plans. Furnish forms capable of maintaining proper alignment during the concrete placement. Ensure connections to structures do not restrict the hydraulic flow of the trench drain.

- Use Class C Concrete conforming to Item 420, "Concrete Structures."

Furnish trench drain rails fabricated with structural steel meeting the requirements of ASTM A 36 with a minimum cross section of 2 in. x 2 in. x 3/16 in. Furnish trench drain rails having 1/4 in. minimum diameter steel anchoring rods at a maximum spacing of 20 in. between each rod, measured in the direction of travel, and a means for securing adjoining trench rails. Furnish steel that is galvanized per ASTM A 123, after fabrication.

Fabricate trench drain grates from ductile iron in accordance with ASTM A 536, Grade 65-45-12 and meet an AASHTO proof load rating of AASHTO M 306. Provide galvanized grates per ASTM A 123, after fabrication.

Furnish stainless grate retainers and rails that withstand the following loads:

- Vertical up-1,000 lbs.
- Transverse-6,000 lbs
- Longitudinal-6,000 lbs

Furnish trench drain grates that have a minimum of 66% open space of total top surface area and are held in place with a non-rigid, four-point locking system in the four corners of the grate. Provide approved trench drain grate retaining devices that do not obstruct the flow area of the trench. Furnish removable trench grates.

Provide shop drawings sealed by a professional engineer stating that trench drain system meets loading requirements or if a proprietary system, submit documents showing design loadings.

Furnish documentation in accordance with Item 471.2.3.

3. CONSTRUCTION

Perform excavation in accordance with Item 400, “Excavation and Backfill for Structures.” Construct trench with a slope as shown on the plans. Submit shop drawings that provide enough detail to ensure seamless installation of the trench drain adjacent to the proposed or existing pavement structure.

If using a proprietary system, provide shop drawings that contain the manufacturer’s installation guidelines and any sequential order of construction. Construct the trench drain with a maximum allowable tolerance of +/- 0.063 in. for dimensional accuracy and rail co-planarity. Provide a smooth finish on the surface of the trench that will convey runoff. Make connections to new or existing structures as shown on the plans or as directed.

Remove trench drain forms and dispose of properly. Install grates with retaining pins on each of the four corners. Remove all construction debris from the trench drain.

4. MEASUREMENT

This item will be measured by the foot, between the longitudinal ends of the trench drain along the pavement surface, as installed.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit bid price for "Trench Drain".

This price is full compensation for furnishing the labor, materials (including forms, rails, anchorages, support bars, concrete, and grates), tools, equipment, and incidentals necessary to install the trench drain, complete in place, including structural excavation, reinforcement anchor, and other connecting devices as shown on the plans and as directed. Structures such as manholes, inlets, or junction boxes connected to the trench drain system will be paid for separately under their respective bid items.

Special Specification 6001
Portable Changeable Message Sign

1. DESCRIPTION

Furnish, operate, and maintain portable trailer mounted changeable message sign (PCMS) units.

2. MATERIALS

Furnish new or used material in accordance with the requirements of this Item and the details shown on the plans. Provide a self-contained PCMS unit with the following:

- Sign controller
- Changeable Message Sign
- Trailer
- Power source

Paint the exterior surfaces of the power supply housing, supports, trailer, and sign with Federal Orange No. 22246 or Federal Yellow No. 13538 of Federal Standard 595C, except paint the sign face assembly flat black.

2.1. **Sign Controller**. Provide a controller with permanent storage of a minimum of 75 pre-programmed messages. Provide an external input device for random programming and storage of a minimum of 75 additional messages. Provide a controller capable of displaying up to 3 messages sequentially. Provide a controller with adjustable display rates. Enclose sign controller equipment in a lockable enclosure.

2.2. **Changeable Message Sign**. Provide a sign capable of being elevated to at least 7 ft. above the roadway surface from the bottom of the sign. Provide a sign capable of being rotated 360° and secured against movement in any position.

Provide a sign with 3 separate lines of text and 8 characters per line minimum. Provide a minimum 18 in. character height. Provide a 5 × 7 character pixel matrix. Provide a message legibility distance of 600 ft. for nighttime conditions and 800 ft. for normal daylight conditions. Provide for manual and automatic dimming light sources.

The following are descriptions for 3 screen types of PCMS:

- **Character Modular Matrix**. This screen type comprises of character blocks.
- **Continuous Line Matrix**. This screen type uses proportionally spaced fonts for each line of text.
- **Full Matrix**. This screen type uses proportionally spaced fonts, varies the height of characters, and displays simple graphics on the entire sign.

2.3. **Trailer**. Provide a 2 wheel trailer with square top fenders, 4 leveling jacks, and trailer lights. Do not exceed an overall trailer width of 96 in. Shock mount the electronics and sign assembly.

2.4. **Power Source**. Provide a diesel generator, solar powered power source, or both. Provide a backup power source as necessary.

2.5. **Cellular Telephone**. When shown on the plans, provide a cellular telephone connection to communicate with the PCMS unit remotely.

3. CONSTRUCTION

Place or relocate PCMS units as shown on the plans or as directed. The plans will show the number of PCMS units needed, for how many days, and for which construction phases.

Maintain the PCMS units in good working condition. Repair damaged or malfunctioning PCMS units as soon as possible. PCMS units will remain the property of the Contractor.

4. MEASUREMENT

This Item will be measured by each PCMS or by the day used. All PCMS units must be set up on a work area and operational before a calendar day can be considered measurable. When measurement by the day is specified, a day will be measured for each PCMS set up and operational on the worksite.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Portable Changeable Message Sign." This price is full compensation for PCMS units; set up; relocating; removing; replacement parts; batteries (when required); fuel, oil, and oil filters (when required); cellular telephone charges (when required); software; and equipment, materials, tools, labor, and incidentals.

Special Specification 6027

Preparation of Existing Conduits, Ground Boxes, or Manholes

1. DESCRIPTION

Prepare conduits, ground boxes, or manholes; replace conduits, ground boxes, or manholes, when necessary; replace conduit fittings with junction boxes; replace damaged ground box or manholes covers; adjust ground box or manholes covers; install pull lines in conduits; install cable racks in ground boxes or manholes.

2. MATERIALS

Provide new materials that comply with the details shown on the plans, the requirements of this Item, and to the pertinent requirements of the following Items:

- Item 624, “Ground Boxes”
- Item 465, “Manholes and Inlets”

When conduit replacement is required, provide conduit meeting the requirements of Item 618, “Conduit.” Use conduit of same size and type of that being replaced or as directed.

Provide 24 in. × 24 in. × 12 in. (L × W × D) minimum size NEMA 4X junction boxes with screw covers.

Provide polyester tapes or rope pull cords with a tensile strength of at least 1200 lb.

Provide heavy duty, non-metallic, non-corrosive cable racks that can support a minimum dead load of 300 lbs. Ensure cable racks are resistant to the effects of oils, hydrocarbons, common esters, ketones, ethers, or amides. Ensure cable racks are adjustable between 8 in. and 14 in. wide. Do not provide grounding or insulators for cable racks.

3. CONSTRUCTION

Check existing conduit and ground boxes.

3.1. **Preparation of Conduit, Ground Box or Manhole**. Pull a mandrel through empty conduits. Use a mandrel with a diameter greater than 70% of the inside diameter of the conduit and 2 in. length. Repair or replace conduit runs that will not allow passage of the mandrel. Replace conduit deemed impractical to repair or remains unsuitable in accordance with Item 618, “Conduit.” Clean the conduit by pulling a rubber swab slightly larger in diameter than the conduit.

Blow compressed air through conduits that contain wires. Remove debris from the conduit by pushing a fish tape through the conduit. Do not use water to clear debris. Retest the conduit by blowing compressed air.

Install 1 pull cord in each conduit for use in installing the conductors, cables, or innerduct. Leave 1 pull cord in each conduit after the conductors, cables, or innerduct have been installed.

Remove silt and debris from ground boxes or manholes prior to installing cable.

3.2. **Installation of Ground Box or Manhole**. Furnish new ground boxes or manholes as directed. Install ground boxes or manholes as shown the plans or as directed.

Backfill disturbed surface with material equal in composition and density to the surrounding area. Replace surfacing material with similar material to an equivalent condition.

3.3. **Installation or Adjustment of Ground Box or Manhole Covers**. Remove, dispose, and install ground box or manhole covers as shown on the plans or as directed. Adjust ground box or manhole covers as shown on the plans or as directed. Adjustment may include welding, raising, or lowering.

Backfill disturbed surface with material equal in composition and density to the surrounding area. Replace surfacing material with similar material to an equivalent condition.

3.4. **Installation of Junction Box**. Locate conduit fittings in conduits carrying fiber optic cables. Replace the conduit fitting and associated section of conduit with a junction box. Install junction boxes as shown on the plans.

3.5. **Installation of Cable Rack Assembly**. Install cable racks to permit coiling of conductors or cables without violating the manufacturer's minimum bending radius. Install 2 cable rack supports and 4 adjustable levels on each support, at a minimum, on each wall of the ground box or manhole as shown on plans or as directed. Anchor the cable rack support permanently to the ground box wall with mechanical or powder actuated fasteners. Use fasteners with an ultimate pull out strength of at least 2500 lb. and ultimate shear strength of at least 3000 lb. Provide sufficient cable supports for the particular number of conductors or cables coiled or passing through the ground box or manhole as shown on the plans or as directed.

4. MEASUREMENT

This Item will be measured by the foot of conduit cleared, tested, replaced and repaired, by each cable rack, junction box, ground box, or manhole installed or prepared, and by each ground box or manhole cover replaced or adjusted.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Conduit (Prepare),” “Junction Box (Install),” “Manhole (Install),” “Ground Box (Install),” “Manhole (Prepare),” “Ground Box (Prepare),” “Cover (Replace)” of the sizes specified, “Cover (Adjust),” and “Cable Rack Assembly (Install).” This price is full compensation for cleaning and testing conduit, ground boxes, and manholes; furnishing and installing pull cords, ground boxes, manholes, junction boxes, and cable racks; excavating and backfilling; adjusting ground boxes and manholes covers; disposal of unsalvageable material; and equipment, materials, labor, tools, and incidentals.

Repair of existing conduit will be paid for by the Department in accordance with Article 9.7., “Payment for Extra Work and Force Account Method.”

Special Specification 6038
Multipolymer Pavement Markings (MPM)

1. DESCRIPTION

Provide MPM on pavement surfaces shown on the plans to meet the performance requirements of this Specification for:

- color,
- durability, and
- retroreflectivity.

2. MATERIALS

2.1. **Multipolymer Pavement Marking Materials.** Use materials that produce an adherent, retroreflective pavement marking system that meets all of the performance requirements of this Specification. Use materials that do not result in the generation of any hazardous materials/wastes, as defined in Section 1.3.60., "Hazardous Materials or Waste," during application or removal. If requested, provide a laboratory report from a commercial laboratory indicating material used does not result in the generation of any hazardous materials/wastes, as defined in Section 1.3.60., during application or removal.

Use a multipolymer resin material, which is:

- 2-component (a predominantly multipolymer pigmented resin component with a curing agent component);
- 100% solids, producing no toxic fumes when heated to application temperature;
- track-free in less than 40 min. with appropriate ambient temperature as recommended by the manufacturer;
- formulated and tested to perform as a pavement marking material with glass spheres applied to the surface; and
- on the Material Producer List for Pavement Markings (Multipolymer) maintained by CST/M&P for MPM. Inclusion onto the MPL requires documentation of acceptable performance from Department pavement marking field application that have been in place for at least 1 yr. Contact CST/M&P to initiate and document field trials of new materials for MPL consideration.

Before work begins, provide a laboratory report from an independent testing laboratory showing that the initial color of each material selected for use conforms to the color limits set forth in Table 1, measured by 45°/0° geometry CIE, D65 Illuminant, 2° standard observation angle in accordance with ASTM E 1347, E 1348, or E 1349.

2.2. **Nonreflectorized Contrast or Shadow Markings.** The marking material used for the contrast or shadow marking must conform to the same formulation, material, prequalification, and sampling requirements with the exception of the following items:

- color pigment used;
- documentation of acceptable performance from Department pavement marking field application that have been in place for at least 1 yr.; and
- glass spheres must be replaced with a black, color-fast, anti-skid material.

Before work begins, provide a laboratory report from an independent testing laboratory showing that the initial color of each material selected for use conforms to the color limits set forth in Table 1, measured by

45°/0° geometry CIE, D65 Illuminant, 2° standard observation angle in accordance with ASTM E 1347, E 1348, or E 1349.

3. EQUIPMENT

Provide equipment as required or directed according to the following:

3.1. **Preparation and Application**. Use equipment designed for the pavement preparation and application of the type of MPM material selected.

3.2. **Colorimeter.** Provide a colorimeter using 45°/0° geometry CIE, D65 Illuminant, 2° standard observation angle meeting the requirements of ASTM E 1347, E 1348, or E 1349.

3.3. **Retroreflectometer.** Unless otherwise shown on the plans, provide a portable or mobile retroreflectometer meeting the following requirements.

3.3.1. **Portable Retroreflectometer.** Provide a portable retroreflectometer that meets the requirements of ASTM E 1710.

3.3.2. **Mobile Retroreflectometer.** Provide a mobile retroreflectometer that:

- is approved by the Construction Division (CST) for project evaluation of retroreflectivity, which will include taking a set of readings on stripes designated by CST and comparing them with the readings of a portable retroreflectometer provided by CST that meets the specifications indicated in this Specification;
- is calibrated daily, before measuring retroreflectivity on any pavement stripe, with a portable retroreflectometer meeting the following requirements: ASTM E 1710, entrance angle of 88.76°, observation angle of 1.05°, and an accuracy of ±15%;
- requires no traffic control when retroreflectivity measurements are taken and is capable of taking continuous readings; and
- documents mobile retroreflectometer evaluations, showing average retroreflectivity values for each 0.25-mi. section, or the area of concern if it is less than 0.25 mi., with all deficient sections clearly marked.

4. CONSTRUCTION

4.1. **General.** Prepare the pavement surface using controlled techniques that minimize pavement damage and hazards to the traveling public. Apply the MPM materials according to the manufacturer's recommendations using widths, colors, and shapes, and at locations as shown on the plans.

Obtain approval for the sequence of work and estimated daily production. Use traffic control as shown on the plans or as approved. Establish guides to mark the lateral location of pavement markings as shown on the plans or as directed, and have guide locations verified. Use material for guides that will not leave a permanent mark on the roadway. Apply markings in alignment with the guides and without deviating for the alignment more than 1 in. per 200 ft. of roadway or more than 2 in. maximum. Remove all applied markings that are not in alignment or sequence as stated in the plans or as stated in the specifications at the Contractor's expense and in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers," except for measurement and payment.

4.2. **Initial Performance Requirements.** Meet the following initial performance requirements after installation. Perform an initial performance evaluation from 7 to 15 days after MPM are installed to verify that the MPM meet the performance requirements for retroreflectivity. Conduct initial retroreflectivity evaluations of placed pavement markings with either a portable or a mobile retroreflectometer, unless otherwise shown on the plans, according to Section 6038.5.2., "Retroreflectivity." The Contractor is responsible for traffic control when conducting performance evaluations.

The Engineer will conduct a visual evaluation for color and durability and require testing only if MPM do not appear to meet the performance requirements.

For MPM not meeting performance requirements, repair or replace until re-evaluation shows the MPM meet the performance requirements.

4.2.1. **Color.** Provide MPM consisting of pigments blended to provide color conforming to standard highway colors as shown in Table 1.

Table1
Color Requirements

Federal 595 Color		Chromaticity Coordinates								Brightness (Y)
		1		2		3		4		
		x	y	x	y	x	y	x	y	
White	17855	.290	.315	.310	.295	.350	.340	.330	.360	60 Min
Yellow	33538	.470	.455	.510	.489	.490	.432	.537	.462	30 Min
Black	-	-	-	-	-	-	-	-	-	5 Max

4.2.2. **Retroreflectivity.** Provide MPM meeting the minimum retroreflectivity values listed in Table 2.

Table2
Minimum Retroreflectivity Requirements

Color	Retroreflectivity, mcd/m^2/lx, Min
White	250
Yellow	175

4.2.3. **Durability.** Provide MPM that do not lose more than 5% of the striping material in a 1,000-ft. section of continuous stripe or broken stripe (25 broken stripes). Pavement markings must remain in the proper alignment and location.

5. PERFORMANCE EVALUATIONS

Provide traffic control and conduct evaluations of color, retroreflectivity, and durability as required or directed.

5.1. **Color.** Measure the color using 45°/0° geometry CIE, D65 Illuminant, 2° standard observation angle in accordance with ASTM E 1347, E 1348, or E 1349.

5.2. **Retroreflectivity.** Unless otherwise shown on the plans, conduct retroreflectivity evaluations of pavement markings with either a portable or a mobile retroreflectometer. Make all measurements in the direction of traffic flow, except for broken centerline on 2-way roadways, where measurements will be made in both directions.

If using a portable retroreflectometer, take a minimum of 1 measurement every mile on each series of markings (i.e., edgeline, center skip line, each line of a double line, etc.), at approved locations. If more than 1 measurement is taken, average the measurements. For all markings measured in both directions, take a minimum of 1 measurement in each direction. If the measurement taken on a specific series of markings within each mile segment falls below the minimum retroreflectivity values, take a minimum of 5 more measurements within that mile segment for that series of marking. If the average of these 5 measurements falls below the minimum retroreflectivity requirements, that mile segment of the applied markings does not meet the performance requirement.

If using a mobile retroreflectometer, review the results to determine deficient sections and deficient areas of interest. These areas do not meet the performance requirements.

5.3. **Durability.** Measure the durability in accordance with ASTM D 913 for marking material loss and visual inspection for alignment and location. Conduct evaluations at approved locations.

6. MEASUREMENT

This Item will be measured by the foot. Each stripe will be measured separately.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

7. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Multipolymer Pavement Markings (MPM)" of the type and color specified and the shape, width, and size specified as applicable, at the time of project acceptance. This price is full compensation for materials, application of MPM, equipment, labor, tools, and incidentals.

Surface preparation, when shown on the plans, will be paid for under Item 678, "Pavement Surface Preparation for Markings."

Special Specification 6185

Truck Mounted Attenuator (TMA) and Trailer Attenuator (TA)

1. DESCRIPTION

Furnish, operate, maintain and remove upon completion of work, Truck Mounted Attenuator (TMA) or Trailer Attenuator (TA).

2. MATERIALS

Furnish, operate and maintain new or used TMAs or TAs. Assure used attenuators are in good working condition and are approved for use. A list of approved TMA/TA units can be found in the Department's Compliant Work Zone Traffic Control Devices List. The host vehicle for the TMA and TA must weigh a minimum of 19,000 lbs. Host vehicles may be ballasted to achieve the required weight. Any weight added to the host vehicle must be properly attached or contained within it so that it does not present a hazard and that proper energy dissipation occurs if the attenuator is impacted from behind by a large truck. The weight of a TA will not be considered in the weight of the host vehicle but the weight of a TMA may be included in the weight of the host vehicle. Upon request, provide either a manufacturer's curb weight or a certified scales weight ticket to the Engineer.

3. CONSTRUCTION

Place or relocate TMA/TAs as shown on the plans or as directed. The plans will show the number of TMA/TAs needed, for how many days or hours, and for which construction phases.

Maintain the TMA/TAs in good working condition. Replace damaged TMA/TAs as soon as possible.

4. MEASUREMENT

4.1. **Truck Mounted Attenuator/Trailer Attenuator (Stationary).** This Item will be measured by the each or by the day. TMA/TAs must be set up in a work area and operational before a calendar day can be considered measurable. When measurement by the day is specified, a day will be measured for each TMA/TA set up and operational on the worksite.

4.2. **Truck Mounted Attenuator/Trailer Attenuator (Mobile Operation).** This Item will be measured by the hour. The time begins once the TMA/TA is ready for operation at the predetermined site and stops when notified by the Engineer. A minimum of 4 hr. will be paid each day for each operating TMA/TA used in a mobile operation.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Truck Mounted Attenuators/Trailer Attenuators (Stationary)," or "Truck Mounted Attenuators/Trailer Attenuators (Mobile Operation)." This price is full compensation for furnishing TMA/TA: set up; relocating; removing; operating; fuel; and equipment, materials, tools, labor, and incidentals.

Special Specification 6438

Mobile Retroreflectivity Data Collection for Pavement Markings

1. DESCRIPTION

Furnish mobile retroreflectivity data collection (MRDC) for pavement markings on roadways as shown on the plans or as designated by the Engineer. Conduct MRDC on dry pavement only. Provider is defined as the Contractor or Subcontractor who collects the MRDC data.

2. EQUIPMENT AND PERSONNEL

2.1. **Mobile Retroreflectometer**. Provide a self-propelled, mobile retroreflectometer certified by the Texas A&M Transportation Institute (TTI) Mobile Retroreflectometer Certification Program.

2.2. **Portable Retroreflectometer**. Provide a portable retroreflectometer that uses 30-meter geometry meeting the requirements described in ASTM E 1710. Maintain, service, and calibrate all portable retroreflectometers according to the manufacturer's instructions.

2.3. **Operating Personnel for Mobile Retroreflectometer**. Provide all personnel required to operate the mobile retroreflectometer and portable retroreflectometer. Ensure MRDC system operator has a current certification from the TTI Mobile Retroreflectometer Certification Program to conduct MRDC with the certified mobile retroreflectometer provided.

2.4. **Additional Personnel**. Provide any other personnel necessary to compile, evaluate, and submit MRDC.

2.5. **Safety Equipment**. Supply and operate all required safety equipment to perform this service.

3. MRDC DOCUMENTATION AND TESTING

Document all MRDC by county and roadway or as directed by the Engineer. Submit all data to the Department and to the TTI Mobile Retroreflectometer Certification Program no later than three working days after the day the data is collected. Submit all raw data collected in addition to all other data submitted. Provide data files in Microsoft Excel format or a format approved by the Engineer. Provide measurement notification and field tests as specified. Verification and referee testing may be conducted at the Department's discretion.

3.1. **Preliminary Documentation Sample**. Submit a sample data file, video, and map of MRDC data in the required format 10 working days before beginning any work. The format must meet specification and be approved by the Engineer before any work may begin.

3.2. **Initial Documentation Review and Approval**. The Department will review documentation submitted for the first day of MRDC, and if it does not meet specification requirements, will not allow further MRDC until deficiencies are corrected. The Department will inform the Provider no later than three working days after submittal if the first day of MRDC does not meet specification requirements. Time charges will continue unless otherwise directed by the Engineer.

3.3. **Data File**. Provide data files with the following:

- date;
- district number;

- county;
- Project CSJ number;
- name of mobile retroreflectometer operator;
- route number with reference markers or other reference information provided by the Engineer to indicate the location of beginning and end data collection points on that roadway;
- cardinal direction;
- line type (single solid, single broken, double solid, etc.);
- line color;
- file name corresponding to video;
- data for each centerline listed separately;
- average reading taken for each 0.1-mi. interval (or interval designated by the Engineer);
- accurate GPS coordinates (within 20 ft.) for each interval;
- color-coding for each interval indicating passing or failing, unless otherwise directed by the Engineer (passing and failing thresholds provided by the Engineer);
- graphical representation of the MRDC (y-axis showing retroreflectivity and x-axis showing intervals) corresponding with each data file;
- distance in miles driven while measuring the pavement markings;
- event codes (pre-approved by the Engineer) indicating problems with measurement;
- portable retroreflectometer field check average reading and corresponding mobile average reading for that interval when applicable; and
- upper validation threshold (may be included separately with the raw data but must be clearly identified with the data collected using that threshold).

3.4. **Map**. Provide a map in an electronic format approved by the Engineer with each MRDC submission that includes the following information:

- date;
- district number;
- county;
- color-coded 1-mi. intervals (or interval length designated by the Engineer) for passing and failing retroreflectivity values or retroreflectivity threshold values provided by the Engineer; and
- percentage of passing and failing intervals, if required by the Engineer.

3.5. **Video**. Provide a high-quality DVD or electronic video file with the following information:

- date and corresponding data file name on label;
- district number;
- county;
- route number with reference markers or other designated reference information to indicate the location of beginning and end collection points on that roadway; and
- retroreflectivity values presented on the same screen with the following information:
  - date;
  - location;
  - starting and ending mileage;
  - total miles;
  - retroreflectivity readings; and
  - upper validation thresholds (may be included separately with the raw data but must be clearly identified with the data collected using that threshold).

3.6. **Field Comparison Checks with a Portable Retroreflectometer**. Take a set of field comparison readings with the portable retroreflectometer at least once every 4 hr. while conducting MRDC or at the frequency designated by the Engineer. Take a minimum of 20 readings, spread out over the interval measured. List the average portable retroreflectometer reading next to the mobile average reading for that interval with the

reported MRDC data. Request approval from the Engineer to take field comparison readings on a separate roadway, when measuring a roadway where portable retroreflectometer readings are difficult to take. Take the off-location field comparison readings at no additional cost. Submit the portable retroreflectometer printout of all the readings taken for the field comparison check with the corresponding MRDC data submitted. The mobile average reading must be within ±15% of the portable average reading. The Engineer may require new MRDC for some or all of the pavement markings measured in a 4-hr. interval before a field comparison check not meeting the ±15% range. Provide the new MRDC at no extra cost to the Department. The Engineer may take readings with a Department portable retroreflectometer to ensure accuracy at any time. The Department's Materials and Tests Division (MTD) will take comparison readings and serve as the referee if there is a significant difference between the Engineer's portable readings and the Provider's mobile and handheld readings. For best results, take field comparison readings on a fairly flat and straight roadway when possible.

3.7. **Periodic Field Checks at Pre-Measured Locations**. When requested by the Engineer, measure with the mobile unit and report to the Engineer immediately after measurement the average retroreflectivity values for a designated pre-measured test location. The Engineer will have taken measurements at the test location within 10 days of the test. The test location will not include pavement markings less than 30 days old. If the measured averages do not fall within ±15% of the pre-measured averages, further calibration and comparison measurements may be required before any further MRDC. Submit the results of the field check with the MRDC report for that day.

3.8. **Measurement Notification**. Provide notification via email to Mobileretro@tamu.edu with a carbon copy to the Engineer a minimum of 24 hr. before mobile retroreflectivity data collection to allow for scheduling verification testing when needed.

3.9. **Verification Testing.** The Engineer or a third party may perform retroreflectivity verification testing within seven days of the Provider's retroreflectivity readings. The Provider-submitted retroreflectivity data will be compared to the verification test data to determine acceptability of the Provider's mobile retroreflectometer data. Comparison of the data will result in one of the two scenarios below:

- Provider's Data is Validated – if the difference between Provider's and Engineer-third party data is 20% or less, then the Provider's data is validated. The Provider's data will be used for acceptance.

- Provider's Data is not Validated – if the difference between Provider's and Engineer-third party data is more than 20%, then the Provider's data is not validated. The Engineer-third party data will be used for acceptance and the Provider will be required to take corrective action before additional Provider data collection and may require re-certification of the mobile retroreflectometer. If the Engineer determines that the Provider's data might be correct then, referee testing may be requested by the Engineer.

3.10. **Referee Testing.** MTD will perform referee testing using portable retroreflectometers to determine if the markings need to be restriped to meet the required retroreflectivity level. The referee test results will be final. Referee testing will be conducted on the verification test sections using the method for portable retroreflectometers specified in Item 666, "Reflectorized Pavement Markings."

4. FINAL REPORT

Submit a final report in the format specified by the Engineer to the Department's Traffic Engineering representative within one calendar week after the service is complete. The final report must contain a list of all problems encountered (pre-approved event codes) and the locations where problems occurred during MRDC.

5. MEASUREMENT

When mobile retroreflectivity data collection for pavement markings is specified on the plans to be a pay item, measurement will be by the mile driven while measuring pavement markings.

6. PAYMENT

Unless otherwise specified on the plans, the work performed, materials furnished, equipment, labor, tools, and incidentals will not be paid for directly, but will be considered subsidiary to bid items of the Contract. When mobile retroreflectivity data collection for pavement markings is specified on the plans to be a pay item, the work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Mobile Retroreflectivity Data Collection." This price is full compensation for providing summaries of readings to the Engineer, equipment calibration and prequalification, equipment, labor, tools, and incidentals.

Special Specification 7361
Automatic Pumping Station

1. DESCRIPTION

Furnish labor, materials, and equipment necessary to construct a stormwater pumping station at SL 8 and UA 90 as shown on the plans that is complete, functional, and fully automatic consisting of, but not limited to the following components.

2. APPROVALS

Upon approval of the above items, construct the pumping station or any portion of it pertaining to the approved items.

If an approved item requires dimensional changes or alterations of the project plans, prepare at no expense to the Department, the necessary plans and submit electronically for approval. Upon approval, proceed with that portion of the pumping station affected by the change.

No changes are permitted in the list of equipment or shop drawings once approved, unless authorized in writing. Approved equipment and plans constitute final plans for construction of the pumping station. Approval, in no way relieves the Contractor or equipment suppliers of any responsibilities described elsewhere in these Specifications.

3. OPERATIONS AND MAINTENANCE MANUALS

Upon determination of the equipment to be used in this station and before final acceptance of this project, furnish the Engineer three binders each containing the following:

Submit documents with 8.5 in. × 11 in. pages, bound in 3-ring or D binders with durable plastic covers. Subdivide contents with permanent page dividers, logically organized to the table of contents, with tab titling clearly printed under reinforced laminated plastic tabs. Prepare a table of contents for each volume, with each product or system description identified.

Part 1–Directory: Listing of names, addresses, and telephone numbers of design consultant, Contractor, subcontractors, and major equipment suppliers.

Part 2–Operation and maintenance instructions, arranged by system. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers and include the following.

- Significant design criteria;
- List of Equipment;
- Parts list for each component;
- Operating instructions;
- Maintenance instructions for equipment and systems; and
- Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

Part 3–Project documents and certificates, including the following.

- Shop drawings and product data,
- Air and water balance reports,
- Certificates, and
- Photocopies of warranties.

Equipment Operation and Maintenance (O&M) Data-Furnish O&M Manuals, prepared by manufacturers for provided equipment. Manuals must contain, as a minimum, the following items.

- Equipment functions, normal operating characteristics, and limiting conditions;
- Assembly, installation, alignment, adjustment, and checking instructions;
- Operating instructions for start-up, normal operation, regulation and control, normal shutdown, and emergency shutdown;
- Lubrication and detailed maintenance instructions. Maintenance instructions are to include detailed plans giving location of each maintainable part and lubrication point and detailed instructions on disassembly and reassembly of equipment;

- Troubleshooting guide;
- Complete spare parts list with predicted life of parts subject to wear, lists of spare parts recommended on hand for both initial start-up and for normal operating inventory, and local or nearest source of spare parts availability;
- Outline, cross-section, and assembly plans; engineering data; wiring diagram;
- Test data and performance curves;
- The complete sequence and full description of operating instructions, noting any precautions; and
- Bound copies of warranties and guarantees with dates of expiration, also names and addresses of persons providing warranties and guarantees.

4. COMPONENTS

4.1. **Basic Mechanical Materials and Methods**. Provide complete Mechanical Systems, including miscellaneous materials, and that are ready for operation in conformance with the plans and specifications.

4.1.1. **Quality Assurance**.

- Materials and Equipment: Use standard products of manufacturers regularly engaged in production of such materials and equipment, unless otherwise indicated.
- Design: Use manufacturer's latest standard design conforming to this Item.
- When two or more units of same class of equipment are required, supply products from the same manufacturer.
- Where materials and equipment are specified to meet requirements of standards or organizations such as Underwriters Laboratories (UL), American Society for Mechanical Engineers (ASME), etc. that use a label or listing as a method of indicating compliance, such label or listing must be attached to the material or equipment when delivered to the jobsite.
- Each major component of equipment must have the manufacturer's name, address, and model number on a metal nameplate attached to the item of equipment.
- Qualifications:
  - Welders must be American Welding Society (AWS) certified.
  - Structural and Miscellaneous Fabricated Steel Used in Equipment must conform to AISC standards, except where otherwise specified,
  - Design structural members for appropriate shock and vibratory loads.
  - Steel partially or totally submerged during operation of equipment must be at least 1/4 in. thick, unless otherwise specified.
  - Materials and Workmanship must conform to standards of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

4.1.2. **Submittals**. The following items are required as part of the submittals.

4.1.2.1. **Product Data. Submit data for materials other than manufacturers' standard products.**

4.1.2.2. **Shop Drawings. Include descriptive and published details concerning performance, capacity, and noise ratings for each piece of equipment.**

- For Electrical Motor-driven Equipment, include schematic drawings showing coordination with electrical system including rated horsepower and full load current requirements.
- For Electric Motors 3/4 Horsepower and larger, furnish the following information:
  - Locked rotor current,
  - Power factor at full and 3/4 load,
  - Efficiency at full load and rated operation condition,
  - Type of bearings,

- Lubrication requirements,
- Net weight, and
- Catalog data for materials other than equipment that are manufacturer's standard products.

■ Provide scaled mechanical layout drawings showing:
- Dimensioned plan views and elevations of mechanical equipment,
- Equipment mounting and foundations, including anchoring details,
- Piping and duct work, including support detail, and
- Components, including space requirements, coordination with building features, and other work.

4.1.2.3. **Quality Assurance and Control Submittals. Provide manufacturer's instructions and recommendations for installation, handling and storage, and cleaning and maintenance of equipment and materials during storage and before initial energizing.**

4.1.2.4. **Certificates.**

■ General: Provide manufacturer's certificates for material and equipment listed.
- Pipe, fittings, and valves 8 in. and smaller in diameter.
- Pipe, fittings, and valves larger than 8-in. diameter: Follow individual specification sections for submittal requirements.

■ Welding: Provide evidence that each welder is certified for type of welding required following AWS.

4.1.3. **Delivery Storage and Handling**.

4.1.3.1. **Packing, Shipping, Handling, and Unloading. Materials and Equipment: Box, crate, or otherwise completely enclose and protect during shipment, handling, and storage, and clearly label with manufacturer's name, brand, or model designation, type or grade, and color.**

Packing Lists and Bills: Include complete packing lists and bills with each shipment.

Tagging and Marking: Each item of equipment tagged or marked with same identification number or mark shown on packing lists and bills of material.

4.1.3.2. **Storage and Protection. Protect materials and equipment from exposure to elements and keep dry. Handle and store to prevent damage, following manufacturers' recommendations.**

■ Protect insulation, controls, and electrical equipment from moisture and water damage.
■ Store pumps, motors, electrical, and other equipment with antifriction or sleeve bearings in weather tight areas maintained above 60°F.

Space heaters furnished in equipment should be connected during storage and operated continuously.

Protect equipment and material from rust, pitting, decay, or other deleterious effects from storage and handling. Repair or replace material and equipment showing such effects or damage, as directed.

4.1.4. **Project Conditions**.

■ General: The plans indicate extent and general arrangement of equipment, piping, and ductwork.
- Fit equipment into space allotted and allow adequate clearance for entry, installation, replacement, servicing, and maintenance.
- Verify actual and final arrangement, location, grades, and elevations of equipment, appurtenances, piping, and ducts before ordering material and equipment.
- If adjustments and modifications are necessary, submit to the Engineer details of such adjustments and modifications and reasons for approval as soon as practicable, but at latest with submittal of scaled mechanical layout drawings.

- Make no adjustments or modifications without Engineer's written approval.

- Coordinate work so equipment may be moved into place without altering building components, other equipment, or installations. Provide drops, rises, or offsets required for proper installation, whether or not shown on the plans.

4.1.5. **Safety Requirements**.

- Enclose or provide guards for belts, pulleys, chains, gears, and other rotating parts to protect operating personnel.
- Guard or cover high-temperature equipment and piping with insulation to protect personnel and prevent fire hazards.
- Provide items such as catwalks, ladders, and guardrails, where required, for safe operation and maintenance of equipment.
- Provide safe working space around equipment.

4.1.6. **Sequencing and Scheduling**. Coordinate sequencing and scheduling of mechanical work with building construction and other related parts of work, including verification that structures, piping, wiring, conduits, and equipment components are compatible.

4.1.7. **Maintenance Materials**. Spare parts and extra materials are specified in the specific specification section for equipment or materials.

- Pack into wooden boxes parts listed to be furnished, and label with:
  - manufacturer’s name, address, and telephone number;
  - local representative's name, address, and telephone number; and
  - names of equipment parts are for and list of parts contained in them.
- Pack extra material in strong cartons, labeled with the manufacturer's name, material name, type, color, and location the material was installed. Store maintenance material in a location directed.

4.1.8. **Manufacturer Services**.

- Ensure Manufacturer’s field representatives of furnished equipment are onsite during installation, start up, tests, and to instruct the Department personnel on operation and maintenance of equipment.
- Ensure factory trained service and operating personnel are available to observe, instruct, guide, and direct the Contractor's handling, installation, start up, and adjustment procedures of equipment.
- Manufacturer's Services:
  - Inspect equipment installed following manufacturer's instructions before energizing or the operating it and supervise equipment start up.
  - Before and during required tests, operate and adjust equipment following plans and specifications.
  - When required in specification sections for equipment, instruct Department personnel in operation and maintenance of equipment at times and locations approved.

4.1.9. **Products**.

4.1.9.1. **General.**

- In the design and supply of equipment, ensure interchangeability of parts and items for equipment, piping, ductwork, motors, and other appurtenances.
- Factory assemble, coat, and paint mechanical equipment as much as practicable before shipping and handling with factory-applied prime coat.
- Nameplate: Attach to each major component of equipment a metal nameplate showing manufacturer's name, address, and equipment model number.

4.1.9.2. **Equipment Bases.**

- Concrete Bases: Unless otherwise indicated, concrete bases must be a minimum of 4-in. thick, and not less than 4-in. larger in both directions than the supported unit.
- Cast Iron or Welded Steel Baseplates: Support each unit and its drive assembly on a single baseplate.

4.1.9.3. **Anchor Bolts.**

- Provide anchor bolts, nuts, and washers that are Stainless Steel, Type 304.
  - Unless otherwise indicated, size anchor bolts to largest diameter that will pass through bolt holes of equipment base.
  - Length of Bolts: To permit minimum 1-in. of grout beneath base plate and minimum of 6-in. anchorage into structural concrete.
- Template or Setting Drawing for Anchor Bolts, Nuts, and Washers: Furnish sufficiently in advance to permit anchor bolts to be set either before or during structural concrete placement.

4.1.9.4. **Supports and Braces. Provide supports and braces fabricated to meet manufacturer's requirements and as indicated on the plans.**

4.1.9.5. **Drive Units. Provide units that meet the following specifications.**

- Nominal Input Horsepower Rating of Gears or Speed Reducers: At least equal to nameplate horsepower of drive motor.
- Drive Units: Designed for 24-hr. continuous service.
- Motor and Drive Gears: Rated AGMA Class II and bearing AGMA nameplate.
- Gear Reducers: Totally enclosed, oil lubricated, with antifriction bearings throughout.
  - Worm Gear Reducers: Service factor of at least 1.20.
  - Shaft-mounted Gear Reducers: Rated AGMA Class II.
  - Other Helical, Spiral Bevel, and Combination Bevel-helical Gear Reducers: Service factor of at least 1.50.
  - Gear Reducer Nameplate: AGMA.
- V belt Drive: Service factor of at least 1.60 at maximum speed, with sliding base or other suitable tension adjustment mechanism.
- Variable Speed Drives: Service factor of at least 1.75 at maximum speed, unless specified otherwise.

4.1.9.6. **Coupling, Bearings, Journals, and Keys. Provide items that meet the following specifications.**

- Couplings: Where specified or required between motor and its driven equipment, use flexible standard self-aligning forged steel coupling.
  - Fix and key one hub of the coupling to the driven equipment shaft with the other hub fixed and keyed to the abutting drive shaft.
  - Place moisture and dust-proof any metal coupling as close as possible to driven equipment and motor bearings so units are arranged in compact manner.
- Bearings: Ball or roller type, with both inner and outer races and balls or rollers made from heat-treated steel, and pressure-grease lubricated, except those specifically requiring lubrication.
  - Rollers: Proper size to carry maximum loads without flaking, spalling, or crushing.
  - Balls: Evenly spaced and held in position by continuous spacing or retainer glands.
- Journals and Bearings: Sized and of proportions to create least wear and overheating under any conditions.
  - Easy Removal and Adjustment: Where required, make provisions for easy removal and adjustments.
  - Journal Lining: When required, line with babbitt metal hammered into grooves and bored in place.
- Keys, Nuts, and Other Parts: Secure parts, which may work loose with locking devices.

4.1.9.7. **Flanges, Jacking Screws, and Eye Bolts.**

- Flange Bolt holes: Drilled with flanges spot-faced on back and stud holes not drilled through.
- Jacking Screws: For covers, where required.
- Eye Bolts for Lifting Covers and Equipment: When manual lifting would be difficult, or where required.

4.1.9.8. **Bolts, Nuts, and Washers.**

- Provide cold pressed nuts.
- For bolts, nuts, and threads, provide American Standard sizes except those used for flanged pipe, valves, fittings, and equipment connections or otherwise noted.

4.1.9.9. **Safety Guards.**

- Cover belt and chain drives, fan blades, couplings, shafts, and other moving and rotating parts on every side with a safety guard following OSHA requirements.
- Fabrication: Galvanized or aluminum clad sheet steel or 1/2-in. mesh galvanized expanded metal, 16 gauge or heavier.
- Design for easy installation and removal, with necessary supports and accessories including bolts.
- Outdoor Guards:
  - Design safety guards in outdoor locations to prevent entrance of rain and dripping water.
  - Safety guards: Follow OSHA requirements.
- Supports and accessories, including bolts: Galvanized or painted following these specifications and as required.

4.1.9.10. **Access Doors and Panels on Mechanical Equipment. Provide access doors and panels for easy access to mechanical components that require periodic maintenance and lubrication.**

4.1.9.11. **Lubrication.**

- Equipment Lubrication System: Design for weekly adjustment during continuous operation.
  - Lubrication Facilities, Oil Drains, and Fill Openings: Accessible from normal operating area or platform.
  - Drain Ports: Allow for collection of waste oil in containers from the operating area or platform without removing the unit from its installed position.
- Pressure Grease Fittings: Zerk Hydraulic or Alemite type.
  - Location: Accessible for lubricating with grease gun.

4.1.9.12. **Shop Painting. Prepare surfaces and shop coat equipment, supports, piping, duct work, and appurtenances, as specified within this Specification and as shown on plans, except connecting ends and where it would hinder installation, using shop primer compatible with field coat. Field paint these points after installation.**

4.1.9.13. **Special Tools and Accessories. Where required for adjusting, maintaining, or repairing equipment, including special devices for lifting and handling, such special tools and accessories must be provided complete with the equipment.**

4.1.9.14. **Electrical Service. Mechanical equipment requiring electrical power to operate must be rated for electrical service as shown on the plans and must have enough length of cable and other appurtenances necessary to provide an operational and full functional unit.**

If the electrical service is not shown on the plans, the Contractor is still responsible for providing such services as required by the equipment manufacturer at no additional cost to the Department.

4.1.9.15. **Examination and Preparation.**

- Inspect areas and surfaces to receive mechanical equipment piping, duct work, and appurtenances, and verify readiness for installation.
- Before installing, repair defects and damaged area, and adjust surfaces and areas for proper installation.
- Field measure and verify adequacy of areas to be occupied by mechanical equipment and appurtenances following approved plans.
- If adjustment is required, obtain the Engineer's approval and adjust as approved.

4.1.9.16. **Installation. Install equipment and appurtenances following manufacturer's instructions. Provide complete final connections to equipment, including pipe, duct, electricity, and controls.**

Isolation Valves and Accessory Fittings: Whether shown or not, install on each side of equipment to allow it to be removed and isolated for servicing. Install manual vents at high points in piping and fit for hose adapters at low points in fluid piping. Install rises and drops as required by field conditions.

4.1.9.17. **Foundations, Bases, and Supports.**

- General: Support equipment, ductwork, electrical conduits, and piping by providing compatible frames, braces, hangers, and anchors.
- Floor-Mounted Equipment: Unless otherwise shown on the plans, place floor mounted equipment on reinforced concrete pads minimum of 4-in. high.
- Horizontal and Vertical Pumps Mounted on Baseplates or Pedestals: Install following Hydraulic Institute Standards and pump manufacturer's recommendations.
  - Leveling of Baseplate or Pedestal: Use shims or wedges and anchor raised vibratory absorption concrete pad with anchor bolts set in pipe sleeves.
  - Grouting: Fill the space between the baseplate or pedestal and concrete pad, and the void between the anchor bolt and pipe sleeve with quick setting and non-shrink grout.
  - Tighten Bolts: After grout has hardened, tighten anchor bolts to equipment manufacturer's recommendations and cut off bolts not more than 1-in. nor less than ½-in. above anchor bolt nut.
- Install vibration isolators between the equipment base and raised concrete pads on other vibrating or rotating mechanical floor-mounted equipment like fans.
- Anchor heavy-duty centrifugal air compressors and blowers following equipment Manufacturer's recommendations.
- Non-vibratory equipment suspended inside buildings should be braced and supported for rigid installation.
  - Attach supports and hangers to bearing walls, roof, and floor supports, or framing members.
  - Install cross bracing as required to develop rigid installation.
- Suspended vibratory equipment should be braced, supported, and provided with cushioning and anti-vibratory material as shown on plans and as recommended by equipment manufacturer.

4.1.9.18. **Access Panels and Doors for Concealed Equipment. Provide access panels or hinged doors where necessary for maintenance and servicing of concealed equipment, piping, ductwork, and fans.**

4.1.9.19. **Lubrication. Lubricate following the manufacturer's instructions for initial operation; relubricate following testing and before final acceptance, if directed.**

4.1.9.20. **Adjustment and Initial Operation of Equipment. Before systems and equipment are initially started, clean piping, ductwork, and equipment.**

- Check moving parts for freedom of movement, alignment, and adjustment.
- Remove air handling units' temporary filters, check permanent filters and replace if dirty or damaged.

Manufacturer's Equipment Service: Adjust as required and recommended by manufacturer's representative and as required herein, before equipment is energized and operated.

4.1.9.21. **Surface Touch-up and Field Painting. Clean field-installed bolts, nuts, washers, and support systems and paint or coat using materials identical to original shop coat and surrounding area. Touch up other surfaces where shop coats have been damaged, using paint, coatings, and film thickness identical to original shop coats. Apply field paint as specified and as shown on the plans.**

4.1.9.22. **Cleaning and Protection. Clean equipment, surrounding area, and ductwork inside and out. Protect equipment during and after installation from construction dust and debris. Provide temporary protection as required until equipment is in operation or until receipt of Certificate of Substantial Completion.**

4.1.9.23. **Field Quality Control. Demonstrate and test operation of systems and equipment for specified requirements, in the Engineer's presence, following requirements of this Item. Adjust and replace defective equipment and parts as required.**

4.1.9.24. **Operation Instructions. After systems have met field quality control requirements and before issuance of Certificate of Substantial Completion, furnish manufacturer's services for operation and maintenance, as specified for equipment in specific sections.**

4.2. **Storm Water Pumps**. Provide labor, materials, equipment, and services necessary to install, test, and place in operation 2 submersible mixed-flow type pumps with explosion proof motors, with column pipes, and cable suspension system shown on the plans and specified herein. Orient the units and other physical characteristics as shown on the plans. Pump motors must be explosion proof and be capable of running on variable-frequency drives (VFD) and soft-starts.

The physical size and weight of the pumps furnished must be capable of being installed in the wet well, as shown on the plans. There are limitations as to the size and weight of pump that will be able to be installed. No additional compensation will be paid for installation of the pumps. The Contractor is responsible for any damage that may occur to a pump during installation and is responsible for repair or replacement to the satisfaction of the Engineer at no additional cost to the Department.

During construction, furnish temporary pumps to maintain the existing pumping rate. Provide necessary design and equipment for the temporary pump.

4.2.1. **Shop Drawings**. Only complete submittal packages including mechanical, electrical, structural, controls, and instrumentation equipment will be reviewed. Partial submittal packages will be returned to the Contractor without review.

Submit the following required information for pumps, motors, and supports.

- General:
  - Dimensions
  - Details of construction and installation
- Motor data:
  - Manufacturer
  - Model
  - Rated horsepower
  - Efficiency
  - Service factor
  - Current and load data
  - Bearing type
  - Bearing calculations

- Weight
- Pump data:
  - Manufacturer
  - Model
  - Certified performance curves with operating points plotted on curves
  - NPSH curves
  - Rated capacities
  - Furnished specialties and accessories
  - Materials of construction
  - Pump orientation
  - Bearing types and lubrication equipment information
  - Seal types
  - Weight
- Pump Start-up and Testing Plan
- Vibration Testing Qualifications
- Operation and Maintenance Manuals

Submit the following for pumping equipment.

- Equipment function, normal operating characteristics, and limiting conditions
- Assembly, installation, alignment, adjustment and checking instructions
- Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions
- Lubrication and maintenance instructions
- Guide to “troubleshooting”
- Parts lists and predicted life of parts subject to wear
- Outline, cross-sections, assembly drawings, engineering data and wiring diagrams
- Test data and performance curves

4.2.2. **References**.

- ASTM A48 – Standard Specification for Gray Iron Castings
- ASTM A743 – Standard Specification for Iron-Chromium Nickel, Corrosion Resistant
- ANSI B16.1 – Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125lb.
- HI 14.6 – Hydrodynamic Pumps for Hydraulic Performance Acceptance Tests
- HI 11.6 – Submersible Pump Tests

4.2.3. **Quality Assurance**. Design and construct the pumps in conformance with standards of the Hydraulic Institute (HI). The efficiency of the pumps, when operating under conditions of the specified capacities and heads, must be as near peak efficiency as practicable.

Obtain pumping equipment, motors, and appurtenances from a single pump supplier whose responsibility it is to ensure that the pumping equipment is properly coordinated and operated in accordance with this Specification.

Design and construct mechanical and electrical equipment in conformance with the latest editions of ANSI, HI, and NEMA Standards.

Submit shop drawings certified for construction by the pump manufacturer which includes location of electrical connections; wiring diagrams; anchor bolt layout; details indicating construction and materials of construction; diameter of shafting; gear and bearing ratings; installation plans showing each pump, suction and discharge piping and fittings, specials, supports, concrete pads, clearances, and dimensions to install the pump in the spaces indicated on the plans.

Qualifications: The manufacturer must have 20 or more years of experience and furnished similar equipment for at least 5 pumping stations.

4.2.4. **Vibration Limits**. The amplitude of vibration of any centrifugal pumping unit, when operating at any of the speeds specified herein must not exceed the requirements set forth in the latest revision of the Hydraulics Institute Standards. The amplitude of vibration for other pumping units must not exceed the requirements of the pump manufacturer's standard.

4.2.5. **Name Plates**. Provide pumps with a stainless-steel nameplate, riveted or bolted to the unit with stainless steel hardware. Nameplates must contain the manufacturer's name, equipment size (i.e., HP, impeller diameter, speed, flow, and head, etc.) and type, serial number, and other pertinent data specified herein.

4.2.6. **Delivery, Storage and Handling**. Preparation for Shipment: Pieces must be delivered in the largest sizes practical for ease of installation within the existing building and ease of minimal field assembly by the Contractor. Permanently tag individual pieces with welded erection marks or stainless-steel tags cross-referenced with information on the manufacturer's erection and assembly drawings. Design field connections for static, live, and erection loads.

Protect drive units, mechanical and electrical components from the weather and suitably package to facilitate handling and storage. Provide special lubricating and rust preventative oils must be provided to prevent internal corrosion of gear assemblies. Always keep mechanical equipment thoroughly dry and store indoors. Equipment stored on the job must be protected and maintained in conformance with the manufacturer's recommendations. When requested, the Contractor must provide written certification from manufacturer that the equipment is being properly stored.

Store pumps onsite under cover in accordance with this Item.

4.2.7. **Rejected material and replacements**. Reject damaged, deteriorated, or contaminated material and immediately remove from the site. Replace rejected materials with new materials at no additional cost to the Department.

4.2.8. **Field Services and Warranty**. Provide services of a manufacturer's representative for not less than 2 days on site for installation inspection and field testing for each pump.

The Engineer has sole discretion to rearrange the configuration of the days of site support. Site visits not used by the manufacturer during the construction period must be made available to the Engineer during the warranty and operations period, not to exceed 2 yr. from the date of conditional acceptance.

Confirm each site visit in writing by a daily log signed by the Engineer and the Manufacturer's representative. Failure of the manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit and will not be attributed to the completion of the total specified number of site visits.

Manufacturer's Warranty: Provide a warranty with a period of 5 yr., with no hour limitation, non-prorated, from the date of final acceptance. The warranty must cover pumps and motors against defects in materials and workmanship, including any parts and factory or authorized service facility labor.

4.2.8.1. **Spare Parts. Contractor must provide the following spare parts per pump.**

- Impeller
- Wear Rings, 1 of each type
- Mechanical Seal
- One thermal sensor (RTD) per installed location

4.2.9. **Products–Stormwater Pumps**.

- Design pump units for installation into a discharge column onto a seat at the bottom of the column that are held in place by its own weight and the pumping head weight. It must be possible to lower the pump in the column and put into operation even when column is filled with water. Ensure there is no need for personal to enter the wet well when removing or reinstalling the pump. The pump must not require any bolts, nuts, or fasteners for connection to the discharge column. Provide an O-ring on the bottom of the inlet (suction) bell mouth so that the weight of the pump unit, when acting on the O-ring, will provide an effective seal between pump and discharge column.
- Provide a motor and pump manufactured by the same manufacturer.
- Coordinate the maximum outer diameter of the pump housing with the installed application. Where the pump is installed in an existing wet well, the pump column must not exceed the existing opening size. Install a locking device, located on the external surface of the pump housing, that prohibits rotational movement of the pump or motor unit within the tube.
- Equip each pump with a submersible electric motor, capable to operate on a 460 volt, 3 phases, 60 hertz voltage supply. The motor must be inverter duty rated for use with VFD and reduced voltage soft starters.
- The pump must be capable to transport river water and 2 in. screened storm sewer.
- Impeller must be made of cast iron, dynamically balanced, multiple-vane, double shrouded non clogging design. It must be equipped with a stainless steel wear ring.
- Equip the suction inlet of the pump housing with a wear ring made of bronze.
- The outlet must have guide vanes designed to minimize clogging by carrying debris normally prone to clog the guide vanes from the inside of the guide vanes towards the outside of the guide vane. Here the flow must be partially and deliberately destabilized to help material disengage itself from the vanes, to continue its passage through and out of the pump.
- Performance Requirements:

Flow	10,500 gpm
Head	32.2 ft
Motor Horsepower (maximum)	135 hp
Motor Speed (maximum)	880 rpm

- The impeller must be mounted on the motor shaft. Couplings or gear boxes will not be accepted.
- The motor must be induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. It must be permanently submersible according standard International Electrotechnical Commission IEC 60034 and protection class IP 68.
- Provide a motor cooled by the pumped water flowing along the stator housing when the pump is working. A water jacket or any external cooling system are not considered acceptable designs.
- Provide a motor capable of at least 15 evenly spaced starts per hour and able to operate throughout the entire pump performance curve from shut-off through run-out. To limit mechanical stress to the motor and the power transmission equipment the start current must be enough to start the driven load at a maximum 3.5 x FLC.
- Provide a stator insulated according to moisture resistant Class H rated for 356°F. The stator windings must be insulated with monomer-free polyester resin resulting in a winding fill rate of at least 96%. The design must be inverter duty rated in accordance with NEMA MG1, Part 31.
- Provide a junction chamber containing the terminal board that is hermetically sealed from the motor by an elastomeric compression seal. Make the connections between the cable conductors and stator leads with threaded compression type binding posts permanently affixed to a terminal board.
- Motor Protection: The motor must motor must be protected by following sensors:
  - 3 bi-metal Thermal switches for thermal control of the stator
  - 1 PT 100 thermal sensor (RTD) to monitor the stator temperature of 1 Winding
  - 1 PT 100 thermal sensor (RTD) to monitor the temperature of the main bearing
  - 1 Vibration sensor to monitor vibration on 3 axes from 10 – 600 Hz.

- 1 float switch in leakage chamber to monitor leakage in the leakage chamber.
- 1 float switch in the terminal connection housing to monitor any leakage thru the cables and the cable entries.

- Furnish a pump supplied with a Pump Electronic Module (PEM) mounted inside the motor. The PEM must collect, store, and digitize measurements from the sensors and communicate the data in a digital format via 2 control leads integral to the pump power cable, to a Base unit mounted in a pump control cabinet to the central control unit. The pump may have no more than one cable entry including power and communication.
- The PEM must also supply information about the pump as well as features for startup and service support, such as:
  - Pump serial number and other data plate information.
  - Specific configuration of monitoring functions for the actual pump such as alarm limits, delays, reset types, etc.
  - Counters by which the system can generate service reminders in conformance with the service policy specified in the pump manual.
  - Operating data and alarm history to analyze the condition of the pump and enable troubleshooting and reporting.
  - Accumulated running time and number of starts.
  - Pump duty rate (percentage of operation).
- Provide a cable entry consisting of dual cylindrical elastomer sleeves, flanked by washers, with a close tolerance fit against the cable and the cable entry. Epoxies, silicones, or other secondary sealing systems are not be considered acceptable.
- The pump shaft must rotate on at least three grease-lubricated bearings. The upper bearing, provided for radial forces, must be a single roller bearing. The lower bearings must consist of at least one roller bearing for radial forces and one or two angular contact ball bearings for axial thrust. The minimum L10 bearing life must be 100,000 hr. at any point along the usable portion of the pump curve at maximum product speed. The lower bearing housing must include a thermal sensor (RTD) of the platinum-100 type to monitor the temperature of the thrust bearing outer race during operation temperature. If a high temperature occurs, the sensor must activate an alarm. The upper support bearing must have an insulated outer ring to provide protection against electrically induced currents that can be created when the motor is used with a VFD.
- Furnish a shaft seal that is a positively driven dual, tandem mechanical shaft seal system consisting of 2 seals, each with an independent spring system. The seal is in a separate lubricant chamber and is lubricated and cooled by environmental friendly medical white oil. The lubricant chamber must be designed to prevent over-filling and must provide capacity for lubricant expansion. It must have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seal system must not rely upon the pumped media for lubrication. The seals must require neither maintenance nor adjustment and must be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal function. The rotating inner seal ring must have small back-swept grooves laser inscribed upon its face to act as a micro pump as it rotates, returning any fluid that should enter the dry motor chamber back into the lubricant chamber. Shaft seals without positively driven tandem mechanical seal or conventional double mechanical seals that are either carried out with a common single or double spring are not acceptable. Any leakage passing the sealing must not pass the bearings. Before it reaches the bearings the liquid must create an alarm via the floating leakage sensor.
- The materials of construction must meet the following specifications.
  - Pump housing & Inlet Cone: ASTM A-48, Class 35B
  - Impeller: Cast iron ASTM A-48, Class 35B
  - Rotating wear ring: stainless steel

- Stationary wear ring: Bronze ASTM B271+B505/C 83600
- Stator housing: ASTM A-48, Class 35B
- Shaft: ASTM A479 S43100-T.
- Shaft seal: Pump side: - Corrosion resistant Tungsten carbide (WCCR)
- Shaft seal Motor side: - Corrosion resistant Tungsten carbide (WCCR)

- Castings must be blasted before coating. Wet surfaces are to be coated with two-pack oxirane-ester Duasolid 50. The total layer thickness must be at least 120 microns. Zink dust primer must not be used.
- Equip the motor with screened cable suitable for submersible pump applications. Coordinate cable length with field installation requirements. Size the power cable according to NEC and ICEA standards. The outer jacket of the cable must consist of oil resistant chlorinated polyethylene rubber. The cable must be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 ft. Supply a cable support grip with the cable.
- Pump Retrieval System: Incorporate the Pump Retrieval System into the pump design. Furnish a pump capable of being removed by a single Type 304 stainless steel wire rope and lifted easily, securely, and safely in one continuous motion. Provide properly sized stainless steel thimble eyes and shackles. Provide a wire rope assembly with a minimum safety factor of 3:1 based on the breaking strength of the wire rope and the weight of the pump. Submit the lifting technique for approval. Use stainless steel hardware.
- Pump Column and Discharge Pipe. Use steel pipe per ASTM A 53 Type E, Grade A or B, API-5L, or ASTM A36 rolled and seam welded plate, sized as shown on plans.
- Weld Flanges. Supply 125 lb., flat face, slip-on registered machined steel in accordance with AWWA C207, Class B. Use full face flange gaskets made of neoprene rubber.
- Provide protective pipe coatings suitable for immersion service. Prepare surfaces per the manufacturer's requirements. Provide one coat Series V69 Hi-build Epoxoline II at 3-4 mils dry film thickness (DFT) and two coats Series 435 Perma-glaze at 7-9 DFT per coat as manufactured by Tnemec or equivalent system. Apply one coat Phenoline 311 at 2-3 mils DFT and one coat Plastie 4500S at 45-55mils DFT as provided by Carboline, or approved equal. Provide color chart for Department selection.
- Gaskets. Provide 125 lb., full face, neoprene rubber gaskets.
- Bolts. Use ASTM A 193-B7 hex head bolts with ASTM A194-2H nuts, hot dip galvanized.
- Adapter Flange. Use mechanical joint type adapter flanges, manufactured from ductile iron, ASTM A536 Grade 65-45-12, Class 125, Series 400 Uni-Flange with set screws and SBR (Buna-S) gasket. Use a galvanized flange.
- T-bolt Hinged Closure. Proved a closure made of carbon steel with a semi-ellipsoidal head hinged to a matching hub prepared for welding to the pipe column, with a self-energizing Buna-N O-ring and a suitable number of T-bolts to effect and maintain a tight seal and is rated at 90 psi min. at 250°F. Ensure it is quickly and easily opened with the cover swung back on its hinges to allow complete and unrestricted access. Supply T-bolts with attached break-over wrenches. Provide a hot dip galvanized closure with proper size pipe couplings for pump cables welded in place.
- Supply pumps from the one of the following manufacturers: Flygt Model LL3356, KSB, or approved equal. Pump basis of design is Flygt. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the contractor with no extra cost to the Department.

4.2.10. **Execution**.

4.2.10.1. **Installation. Install the pumping systems in complete compliance with applicable requirements of the latest edition of ANSI/HI and the manufacturer's recommendations. Remove the existing sump pumps from operation before initiation of activities within an area. Install and maintain temporary sump pumps for the duration of construction activities within an area.**

4.2.10.2. **Startup Services and Training. The manufacturer must furnish the service of a qualified, factory-trained service representative who must inspect the complete equipment installation under the supervision of the Pump Control System Supplier to ensure that it is installed in conformance with the manufacturer's recommendations, make any adjustments necessary to place the system in trouble-free operation, and instruct the operating personnel in the proper maintenance and operation of the equipment furnished.**

The Department reserves the right to videotape and archive startup and training instruction provided by the manufacturer or authorized representative.

After the pumps have been completely installed and wired, the manufacturer's service representative must perform the following.

- Megger stator and power cables
- Check seal lubrication.
- Check for proper rotation.
- Check power supply voltage.
- Measure motor operating load and no-load current.
- Check level control operation and sequence.
- Make any adjustments, as necessary.

Furnish a written startup report providing measurements and readings, confirming checks and inspections, indicating adjustments made, and certifying that the installation and operation is in compliance with the specifications and the pump manufacturer's recommendations. The manufacturer's representative must provide tools and test equipment required to perform testing. Should the manufacturer's representative fail to provide the necessary testing equipment, the startup will be rescheduled at the Contractor's expense. The Contractor will not be entitled to additional time or money due to the need to reschedule testing.

Startup services pertaining to instrumentation and control must be under the supervision of the Pump Control System Supplier.

4.2.10.3. **Testing.**

4.2.10.3.1. **Factory Testing**. Perform testing of each pump on a Hydraulic Institute (HI) compliant test stand in a facility located in one of the contiguous 48 United States. Test each pump in conformance with the latest HI Standards and must include the following:

- Check impeller, motor rating, and electrical connections for compliance with this specification.
- Before testing, run each pump to establish correct rotation.
- Each pump must be run in air.
- Test motor and cable insulation for moisture content for insulation defects.

Furnish in writing a quality assurance record for each pump, confirming the above inspections and testing, at the time of the shipment.

Test each pump supplied in conformance with the latest HI Standards at the factory to determine the criteria listed below. Performance curves for the listed criteria must be based on a minimum of seven evenly spaced test points, including shutoff (or as near to it as possible), 1/4, 1/2, 3/4, 4/4, and two additional points. Perform testing points as provided in accordance with HI Test Acceptance Grade 1U; no negative tolerances will be allowed for any tested parameter. At a minimum, provide performance curves for pump and motor

speeds of 50%, 75%, 100%, and the two speeds required to meet the design flow and minimum flow listed above. Test each supplied pump for the following criteria:

- Pump head and efficiency versus capacity,
- Motor power, efficiency, and horsepower draw versus capacity, and
- Pump Net Positive Suction Head Required (NPSHR) vs capacity.

Furnish 8 copies of certified performance curves and test reports for each pump before shipment. Report data in Standard English units.

4.2.10.3.2. **Field Testing**. Perform field tests for the purpose of accepting the pumps for mechanical integrity. Submit a proposed test procedure to the Engineer for approval. The Contractor must provide necessary instrumentation.

Perform tests with potable water only. The Contractor is responsible for providing water used for testing.

Tests must first establish that the pump H-Q curves are roughly tracking the factory test curves. At a minimum, 5 evenly spaced test points must be provided. These must include, while the pump is running at full speed: shutoff, full capacity, 1/2 capacity and two additional points as directed. Record motor amps and pressure for each point.

After determining that the pumps are performing per the factory H-Q curves, exercise the pump for not less than 1 hr. per pump. Demonstrate that pump, motor, and vibration does not exceed ANSI/HI limits and bearing temperatures do not exceed the manufacturer's recommendations. Vibration testing must be performed by a qualified independent testing agency.

Procure the services of an independent vibration testing agency to measure the vibration and the operating speed of the modified pumping unit under actual operating conditions.

Conduct testing in the presence of the Engineer. Testing must be conducted by a firm or individual whose qualifications are subject to the approval of the Engineer. Testing results must be documented by the Contractor and submitted to the Engineer for approval.

If any equipment fails the vibration tests, replace such equipment or make adjustments until vibration falls within the specified limits. Perform replacement, adjustments, and retesting entirely at no additional cost to the Department.

4.3. **Sludge Pump**. Provide labor, materials, equipment, and services necessary to furnish, install, test, and place in operation a submersible solids handling type pump with explosion proof motor as shown on the plans and specified herein. Orient the units and other physical characteristics as shown on the plans.

Provide sludge pumps of the physical size and weight of the pumps capable of being installed in the wetwell, as shown on the plans. There are limitations as to the size and weight of pump that will be able to be installed. No additional compensation will be paid for installation of the pumps. The Contractor will be responsible for any damage that may occur to a pump during installation and will be responsible for repair or replacement to the satisfaction of the Engineer at no additional cost to the Department.

4.3.1. **Shop Drawings**. Only complete submittal packages including mechanical, electrical, structural, controls and instrumentation equipment will be reviewed. Partial submittal packages will be returned to the Contractor without review.

Submit the following required information for pumps, motors and supports.

- General:
  - Dimensions
  - Details of construction and installation

- Motor data:
  - Manufacturer
  - Model
  - Rated horsepower
  - Efficiency
  - Service factor
  - Current and load data
  - Bearing type
  - Bearing calculations
  - Weight
- Pump data:
  - Manufacturer.
  - Model.
    - Certified performance curves with operating points plotted on curves.
    - NPSH curves
    - Rated capacities
    - Furnished specialties and accessories.
    - Materials of construction.
    - Pump orientation.
    - Bearing types and lubrication equipment information.
    - Seal types.
    - Weight.
- Pump Start-up and Testing Plan
- Vibration Testing Qualifications
- Operation and Maintenance Manuals:

Submit the following required information for the pumping equipment.

- Equipment function, normal operating characteristics and limiting conditions
- Assembly, installation, alignment, adjustment and checking instructions
- Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions
- Lubrication and maintenance instructions
- Guide to “troubleshooting”
- Parts lists and predicted life of parts subject to wear
- Outline, cross-sections, assembly drawings, engineering data and wiring diagrams
- Test data and performance curves

4.3.2. **References**.

- ASTM A48 – Standard Specification for Gray Iron Castings
- ASTM A743 – Standard Specification for Iron-Chromium Nickel, Corrosion Resistant
- ANSI B16.1 – Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125lb.
- HI 14.6 – Hydrodynamic Pumps for Hydraulic Performance Acceptance Tests
- HI 11.6 – Submersible Pump Tests

4.3.3. **Quality Assurance**. Design and construct the pumps in conformance with standards of the Hydraulic Institute. The efficiency of the pumps, when operating under conditions of the specified capacities and heads, must be as near peak efficiency as practicable.

Obtain pumping equipment, motors, and appurtenances from a single pump supplier whose responsibility it is to ensure that the pumping equipment is properly coordinated and operated in accordance with this Item.

Design and construct mechanical and electrical equipment in conformance with ANSI, HI, and NEMA Standards, latest editions.

Submit shop drawings certified for construction by the pump manufacturer which includes location of electrical connections; wiring diagrams; anchor bolt layout; details indicating construction and materials of construction; diameter of shafting; gear and bearing ratings; installation drawings showing each pump, suction and discharge piping and fittings, specials, supports, concrete pads, clearances, and dimensions to install the pump in the spaces indicated on the plans.

Qualifications: The manufacturer must have 20 or more years of experience and furnished similar equipment for at least 5 pumping stations.

4.3.4. **Vibration Limits**. The amplitude of vibration of any centrifugal pumping unit, when operating at any of the speeds specified herein must not exceed the requirements set forth in the latest revision of the Hydraulics Institute Standards. The amplitude of vibration for any other pumping units must not exceed the requirements of the pump manufacturer's standard.

4.3.5. **Name Plates**. Provide each pump with a stainless-steel nameplate, riveted or bolted to the unit with stainless steel hardware. Nameplates must contain the manufacturer's name, equipment size (i.e., HP, impeller diameter, speed, flow, and head, etc.) and type, serial number, and other pertinent data specified herein.

4.3.6. **Delivery, Storage and Handling**. Preparation for Shipment: Deliver pieces in the largest sizes practical for ease of installation within the existing building and ease of minimal field assembly by the Contractor. Individual pieces must be permanently tagged with welded erection marks or stainless-steel tags cross-referenced with information on the manufacturer's erection and assembly drawings. Field connections must be designed for static, live, and erection loads.

Protect drive units, mechanical, and electrical components from the weather and suitably package to facilitate handling and storage. Provide special lubricating and rust preventative oils to prevent internal corrosion of gear assemblies. Always keep mechanical equipment thoroughly dry and store indoors. Protect equipment stored on the job and maintain in conformance with the manufacturer's recommendations. When requested, provide written certification from manufacturer that the equipment is being properly stored.

Store pumps on site under cover in accordance with this Item.

4.3.7. **Rejected Material and Replacements**. Reject damaged, deteriorated, or contaminated material and immediately remove from the site. Replace rejected materials with new materials at no additional cost.

4.3.8. **Field Services and Warranty**. Provide services of a manufacturer's representative on site for a minimum of 2 days for installation inspection and field testing for each pump.

The Engineer may elect to rearrange the configuration of the days of site support at his sole discretion. Site visits not used by the manufacturer during the construction period must be made available to the Engineer during the warranty and operations period, not to exceed 2 yr. from the date of conditional acceptance.

Confirm in writing each site visit by a daily log signed by the Engineer and the Manufacturer's representative. Failure of the Manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit and will not be attributed to the completion of the total specified number of site visits.

Manufacturer's Warranty should cover a period of 5 yr., with no hour limitation, non-prorated, from the date of final acceptance. The warranty must cover pumps and motors against defects in materials and workmanship, including parts and factory or authorized service facility labor.

4.3.9. **Spare Parts**. Provide the following spare parts for each pump: Impeller and 1 of each type of wear ring.

4.3.10. **Products–Sludge Pumps**. Ensure it is possible to lift and lower the pump on parallel guide bars and connect it to the wet well mounted discharge connection. There must be no need for personal to enter the wet well when removing or reinstalling the pumps.

Sealing of the pump unit to the discharge connection must be accomplished by a machined metal to metal watertight contact. Sealing of the pump discharge interface with an O-ring, diaphragm or profile gasket is not acceptable.

The impeller must be a semi open multi vane self-cleaning impeller designed to transport wastewater with fibrous materials like wet wipes. Impeller must be wear resistant against sand and grit which is expected to enter the pump station with the sewage or storm water.

Performance Requirements:

Flow	550 gpm
Head	36 ft
Motor Horsepower (maximum)	7.5 hp
Motor Speed (maximum)	1,961 rpm

The NPSHR must be below 16-ft. depth.

The manufacturer must guarantee clog-free operation for a period of 24 months from the date of start-up of the pumps by the local authorized factory representative. A certificate must be provided to the Department on the day of start up with the local contact information and effective date. Should the impeller clog with typical solids or modern trash debris normally found in domestic wastewater during this period, an authorized representative must, either travel to the jobsite, remove the pump, clear the obstruction, and reinstall the pump at no cost or reimburse the Department for reasonable cost to provide this service. Provide a written report to the Department detailing the service call with pictures for verification purposes.

Equip the pump with a submersible synchronous electric motor, capable to operate on a 380-480 volt, 3 phase, 60 hertz voltage supply. The starting current must not exceed 14 A.

Pump must be capable of handling raw domestic wastewater or stormwater with fibrous materials like wipes.

The impeller blades must be self-cleaning upon each rotation as they pass across a sharp relief groove in the insert ring that keeps the impeller blades clear of debris. The insert ring must have a guide pin which moves fibers from the center of the impeller to the leading edges of the impeller. The impeller must move axially upwards to allow larger debris to pass through and immediately return to normal operating position. The clearance between the insert ring and the impeller leading edges must be adjustable.

Due to the likely presence of sand and or grit, furnish the impeller and the cutting ring made of ASTM A532 Alloy III A with 25% chrome. Impellers that have surface hardening or coating will not be allowed.

The pump must be capable to operate without any limitation between 50% and 150% of the best efficiency point (B.E.P.) of the performance curve.

The pump the motor and the integrated control system must be submersible a minimum of 65 ft. according to IEC 60034 and protection class IP 68. Motors which only can be submerged for a limited time (IP 67) must not be considered as equal.

The motor must be capable to operate the pump at continuous duty (S1) in an ambient temperature up to 104°F. Operational restrictions or the demand of auxiliary cooling systems like fans or blowers are not acceptable.

The pump must be operated by a synchronous motor and an integrated control system and be capable to run at constant power at any point of the performance field without being overloaded. The motor must use a permanent magnet rotor to maintain synchronous speed.

The motor must be capable of withstanding at least 60 starts per hour. Motor must be explosion proof rated.

The discharge flange of the pump must be 4-in. minimum and drilled according to ANSI B16.1-89; Table 5.

The impeller must be mounted on the motor shaft. Couplings will not be accepted.

Equip pumps with an integrated pump control system installed in the pump or motor housing which must start the pump by gradually increasing the pump speed. The starting current must not be higher than the rated current.

An integrated pump control system installed in the pump motor housing must secure the correct direction of the impeller rotation. There must be no need for any human intervention to ensure that the impeller is rotating in the correct direction within the volute. The integrated control system must be inside the motor and encapsulated to protect it against moisture ingress and vibration.

The motor and the pump control system must receive enough cooling from the pumped liquid to continuously operate the pump in a liquid at a temperature of 104°F. Operational restrictions on the liquid temperature below 104°F or the demand of auxiliary cooling systems like fans or blowers are not acceptable. The stator must be inverter duty rated in accordance with NEMA MG1, Part 31 and be insulated according Class H (356°F).

Motor, pump, and control system must be designed and supplied by the pump manufacturer.

The control system must continuously monitor the leakage sensor in the stator housing and the temperature of the motor. It must be impossible to overload the motor. If the motor temperature is too high, the pump must continue to operate at reduced power until conditions are normalized. External trips or overload devices for motor protection must not be required.

The operator must be able to modify the setting of the control system to decide if the active leakage signal must stop or not stop the pump.

The pump must incorporate a “pump-cleaning” function to remove debris from the impeller. The cleaning function must be initiated when the integral control system senses an increase in current draw due to debris in the pump. The cleaning function must consist of forced stopping, reversal, and forward runs timed to allow for debris to fall from the impeller. After the cleaning cycle is complete, the pump must resume to automatic operation. If the pump impeller or volute does not clear itself after the programmed number of attempts, the control must initiate an alarm to notify that the pump inlet or volute is blocked by large debris.

Provide a Human Machine Interface (HMI) making it possible to access and adjust the pump system. The HMI should consist of a unit ranging from basic monochrome displays to full-color touch screen units and smartphone or tablet. It must enable the operator to view and control entire pump system and logged operational data like number of starts, avoided clogging instances, pump run-time, motor power, motor current, power factor, temperature, pump leakage etc.

Provide 15 in. HMI/OIT PCP and Sludge Pump Control Panels, manufactured by Harmony GTU, Magelis GTU, or approved equal. Supply HMI/OIT panels with necessary HMI hardware, drives, and other development tools to provide a complete and functions system in conformance with the plans and specifications.

The shaft must rotate on two bearings. The motor bearings must be sealed and permanently grease lubricated with high temperature grease. The upper motor bearing must be a single-row ball bearing to handle radial loads. The lower bearing must be a double-row, angular contact ball bearing to handle the thrust and radial forces. Single row lower bearings are not acceptable. The minimum allowable L10 bearing life should be 50,000 hr. at any usable portion of the pump performance field.

The shaft must be sealed by a tandem mechanical shaft seal system consisting of two seals, each with an independent spring system. The seals must require neither maintenance nor adjustment and must be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal function.

Where a seal cavity is present in the seal chamber, the area about the exterior of the lower mechanical seal in the cast iron housing must have cast in an integral concentric spiral groove. This groove must protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

Provide the following materials for construction:

- Pump housing: ASTM A-48, Class 35B
- Impeller and insert ring: A 532 ALLOY III A (25% chrome)
- Stator housing: GD-AL SI 12 or ASTM B85A 413
- Shaft: ASTM A479 S43100-T.
- Shaft seal: Pump side: - Corrosion resistant Tungsten carbide (WCCR)
- Shaft seal Motor side: - Corrosion resistant Tungsten carbide (WCCR)

Blast castings before coating. Coat wet surfaces with two-pack oxirane ester Duasolid 50. The total layer thickness must be at least 120 microns. Zinc dust primer must not be used.

Equip the motor with screened cable S3x6+3x6/3+S(4x0,5) suitable for submersible pump applications. Coordinate cable length with field installation requirements. Size the power cable according to NEC and ICEA standards. The outer jacket of the cable must be oil resistant chlorinated polyethylene rubber. The cable must be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 ft.

Supply each pump with a mating cast iron discharge connection. The pumps must be automatically and firmly connected to the discharge connection, guided by at least two stainless steel guide bars extending from the top of the station to the discharge connection to ensure pump stability when installing or removing the machine. There must be no need for personnel to enter the wet well to access the pump. Seal the pumping unit to the discharge connection by a machined metal to metal watertight contact. Sealing the discharge interface with a diaphragm, O-ring, or profile gasket will not be acceptable. No portion of the pump can bear directly on the wet well floor.

The guide rail system must consist of two parallel 2” guide bars, supported by pump manufacturer supplied upper guide rail brackets. Guide bars and guide brackets must be Type 304 Stainless Steel.

Fit each pump with stainless steel lifting cable. Connect lifting cable to the lifting handle of the pump and be long enough to reach the top elevation of the station. Lifting chain must be compatible with the Grip-Eye Pump Lift System. The working load of the lifting system must be 50% greater than the pump unit weight.

Provide one pump lift system Grip-Eye for each pump. The Grip-Eye must allow for utilizing a hoist for lifting each pump from its installed position to above the top elevation of the station. Configure the Grip-Eye device to slide down the stainless-steel lifting chain and grip the lifting chain near pump handle. Size the retrieval system for the weight of the pump to be lifted.

Supply submersible cable connection boxes meeting the requirements of NEMA 6P. Connect the pump submersible cable to the wall-mounted power and monitoring cables in a cable connection box to ease the installation and disassembling of the pumps. The cable connection box must be submersible NEMA 6P (IP 67) to ensure that no water can enter the motor via the cables even when the station is flooded.

Sump Pump Discharge Line. Provide the following components:

- Discharge Pipe and Fittings. Provide flanged ductile iron, Class 54 pipe with Protecto 401 ceramic epoxy lining. Provide Class 125 flanges and coordinate flanges with the connecting equipment. Where flange adapters are necessary, utilize EBAA Iron Megaflange 2100 or equivalent from Star Pipe Products. Provide fittings and pipe from the same manufacturer. Provide 1/8" thick, AWWA C207 gaskets. Test piping in accordance with AWWA C600 to 1-1/2 times the working pressure, but not less than 150 psi.
- Provide protective pipe coatings suitable for immersion service. Prepare surfaces per the manufacturer's requirements. Provide one coat Series V69 Hi-build Epoxoline II at 3-4 mils dry film thickness (DFT) and two coats Series 435 Perma-glaze at 7-9 DFT per coat as manufactured by Tnemec or equivalent system. Provide one oat of Phenoline 311 at 2-3 mils DFT and one coat Plastie 4500S at 45-55mils DFT as provided by Carboline, or approved equal. Provide color chart for Department selection.
- Bolts. Provide stainless steel bolts and nuts for flanged piping, fittings, and couplings.
- Pipe Coupling. Provide restrained coupling as manufactured by Smith Blair, Romac, Dresser, Rockwell, or equal. Provide high strength stainless steel nuts and bolts.
- Check Valve. Provide iron body, sinking ball type check valve, flanged, suitable for vertical installation with exterior coating per manufacturer standard coating. Design of valve will be non-clogging and self-cleaning. Valve will be resilient seated and provide full port flow path. Provide ductile iron bonnet, stainless steel bolts, and aluminum core ball vulcanized with rubber on the sides. Provide valve from VAG Group, G.A. Industries, or approved equal.

4.3.11. **Execution**.

4.3.11.1. **Installation. Install the pumping systems in complete compliance with applicable requirements of the latest edition of ANSI/HI and the manufacturer's recommendations. Remove existing sump pumps from operation before initiating activities within an area. Install and maintain temporary sump pumps for the duration of construction activities within an area.**

4.3.11.2. **Startup Services and Training. Furnish the service of a qualified, factory-trained service representative who must inspect the complete equipment installation under the supervision of the Pump Control System Supplier to ensure that it is installed in conformance with the manufacturer's recommendations, make any adjustments necessary to place the system in trouble-free operation, and instruct the operating personnel in the proper maintenance and operation of the equipment furnished.**

The Department reserves the right to videotape and archive startup and training instruction provided by the manufacturer or authorized representative.

After the pumps are completely installed and wired, the manufacturer's service representative must perform the following:

- Megger stator and power cables.

- Check seal lubrication.
- Check for proper rotation.
- Check power supply voltage.
- Measure motor operating load and no-load current.
- Check level control operation and sequence.
- Make any adjustments, as necessary.

Furnish a written startup report providing measurements and readings, confirming checks and inspections, indicating the adjustments made, and certifying that the installation and operation is in compliance with the specifications and the pump manufacturer's recommendations. The manufacturer's representative must provide the tools and test equipment required to perform testing. Should the manufacturer's representative fail to provide the necessary testing equipment, the startup will be rescheduled at the Contractor's expense. The Contractor will not be entitled to additional time or money due to the need to reschedule testing.

Startup services pertaining to instrumentation and control must be performed under the supervision of the Pump Control System Supplier.

4.3.12. **Testing**.

4.3.12.1. **Factory Testing. Test each pump on a Hydraulic Institute (HI) compliant test stand in a facility located in one of the contiguous 48 United States. Test each pump in conformance with the latest HI Standards and include the following.**

- Check impeller, motor rating, and electrical connections for compliance with this Specification.
- Before testing, run each pump to establish correct rotation.
- Each pump must be run in air.
- Test motor and cable insulation for moisture content for insulation defects.

Furnish a writing quality assurance record for each pump, confirming the above inspections and testing, at the time of the shipment.

Test each supplied pump in conformance with the latest HI Standards at the factory to determine the criteria listed below. Performance curves for the listed criteria must be based on a minimum of 7 evenly spaced test points, including shutoff (or as near to it as possible), 1/4, 1/2, 3/4, 4/4, and 2 additional points. Perform testing points in accordance with HI Test Acceptance Grade 1U; no negative tolerances will be allowed for any tested parameter. At a minimum, provide performance curves for pump and motor speeds of 50%, 75%, 100%, and the 2 speeds required to meet the design flow and minimum flow listed above. The following criteria must be tested for each supplied pump.

- Pump head and efficiency versus capacity.
- Motor power, efficiency, and horsepower draw versus capacity.
- Pump Net Positive Suction Head Required (NPSHR) vs capacity.

Furnish 8 copies of certified performance curves and test reports for each pump before shipment. Report data in Standard English units.

4.3.12.2. **Field Testing. Run field tests for the purpose of accepting the pumps for mechanical integrity. Submit a proposed test procedure to the Engineer for approval. Provide the necessary instrumentation.**

Perform tests with potable water only. The Contractor is responsible for providing water for any testing.

Tests must first establish that the pump H-Q curves are roughly tracking the factory test curves. At a minimum, 5 evenly spaced test points must be provided. These must include, while the pump is running at full speed: shutoff, full capacity, 1/2 capacity and 2 additional points as directed. Record motor amps and pressure for each point.

After determining that the pumps are performing per the factory H-Q curves, exercise the pumps for not less than 1 hr. per pump. Demonstrate that the pump, motor, and vibration do not exceed ANSI/HI limits and bearing temperatures do not exceed the manufacturer's recommendations. Vibration testing must be performed by a qualified independent testing agency.

Procure the services of an independent vibration testing agency to measure the vibration and the operating speed of the modified pumping unit under actual operating conditions.

Testing Agency Qualifications: Conduct testing in the presence of the Engineer. Testing must be conducted by a firm or individual whose qualifications are subject to the approval of the Engineer. Document testing results and submit to the Engineer for approval.

If any equipment fails the vibration tests, replace or adjust such until vibration falls within the specified limits. Replacement, adjustments, and retesting must be performed entirely at Contractor's expense.

4.4. **Flap Gate**. The contractor must furnish labor, materials, and equipment required for installation of flap valves.

4.4.1. **Quality Assurance**. The manufacturer must have at least 10 yr. experience manufacturing flap valves and must show evidence of satisfactory operation in at least 5 installations. The company must be ISO 9001 certified.

Flap gates, wall thimbles, and related equipment must be designed, manufactured, and installed in conformance with the best practices and methods, and must operate satisfactorily when installed as shown on the plans.

Provide flap gates from a single manufacturer.

Furnish new and unused equipment that are standard products of manufacturers with a successful record of manufacturing and servicing the equipment and systems specified herein.

Manufacturer's Representative Services. Provide a factory representative who has complete knowledge of proper operation and maintenance for at least one 8-hr. day (exclusive of travel time) to instruct representatives of the Department on the proper operation and maintenance of the equipment. If there are difficulties in operation of the equipment due to the manufacturer's fabrication or the Contractor's installation, additional service must be provided at no change in Contract price or time.

4.4.2. **Submittals**. The manufacturer must submit drawings showing critical dimensions, general construction, and materials used in the valve. Submittals must include the following.

- Complete description of the materials.
- Certified shop and installation drawings showing details of construction, dimensions, and anchor bolt locations and sizes.
- Descriptive bulletins, and catalogs of the equipment.
- Complete bill of materials.
- A list of manufacturer's recommended spare parts with the manufacturer's current price for each item. Include gaskets, packing, etc. on the list. List bearings by bearing manufacturer's numbers only.
- Design calculations for the gate. Calculations must identify loading conditions, anchorage, and must verify that stresses and deformations will not impair operation and are within specification requirements. These calculations must be stamped by a Professional Engineer Licensed in the state of installation.

Operation and maintenance instructions. Provide a list of the manufacturer's recommended set of spare parts and prices required for normal operation and maintenance.

Submit the following Test Reports.

- Description of test procedures and equipment.
- Copies of test results.

4.4.3. **Field Services and Warranty**. Provide services of manufacturer's representative onsite for installation inspection and field testing. Provide for the above services to be performed during separate visits to the project site. Notification of coordinating the site visits must be provided to the Engineer in writing a minimum of 14 days in advance of each site visit. The Engineer reserves the right to reschedule each of the site visits with a 7-day period.

Each site visit must be confirmed in writing by a daily log signed by the Engineer and the Manufacturer's representative. Failure of the Manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit made and will not be attributed to the completion of the total specified number of site visits.

After each installation, inspection, field testing, and start-up trip a written report covering the representative's findings must be submitted. Report must include inspection findings, field test results, installation approval, any deficiencies noted, and remedies for the deficiencies. Trip reports must be submitted within 3 days following the field service.

The manufacturer must warrant equipment manufactured by it to be free from defects in workmanship or material for a period of 2 yr. from date of conditional acceptance. If during said warranty period, any components prove to be defective in workmanship or material under normal use and service they will be replaced or repaired free of charge, inclusive of freight and labor.

4.4.4. **Delivery, Storage, and Handling**. Properly store and protect parts so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is complete and the units are ready for operation. Properly protect equipment and parts against any damage during a prolonged period at the site. Factory assembled parts and components must not be dismantled for shipment unless permission is received in writing from the Engineer. Finished iron or steel surfaces not painted must be properly protected to prevent rust and corrosion. Do not ship equipment until approved in writing.

4.4.5. **Products**.

4.4.5.1. **General Design for Flap Gate.**

- Flap gates must open when there is a differential pressure across the flap of 6-in. or less.
- Flap gates must be substantially watertight under design load head conditions.
- Under the design seating head, the leakage must not exceed 0.10 US gpm per ft. of seating perimeter.
- Flap valve must have a cast iron body and cover.
- Seat and disc ring must be bronze, and the hinge pin and cotter pins must be stainless steel.
- Valve must be constructed with a 10-degree offset from vertical to ensure positive closure.
- The flange must be drilled using an ANSI 125# template.
- All iron parts must be coated in TNEMEC 2-part epoxy with 3-4 mils dry film thickness to prevent rusting or corrosion.
- The valve must be machined, assembled, and tested in the USA for quality assurance.
- The manufacturer must show proof of ISO 9001 certification.
- Valve and accessories must be manufactured by Troy Valve, Model A2540, Kenedy or approved equal. Flap gate basis of design is Troy Valve. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the Contractor with no extra cost to the Department.

4.4.5.2. **Factory Inspection and Testing. Perform factory inspection, testing, and correction of deficiencies in conformance with the referenced standards and as noted herein.**

4.4.6. **Execution**.

4.4.6.1. **General.**

- Install appurtenances per the manufacturer's instructions in the locations shown, true to alignment and rigidly supported. Repair any damage to the above items to the satisfaction of the Engineer before installing.
- Assume responsibility for the proper location of gates and appurtenances during the construction of the work.
- Carefully inspect materials for defects in construction and materials. Clean out debris and foreign material out of openings, etc. Check operating mechanisms for proper functioning and check nuts and bolts for tightness. Repair or replace equipment which does not operate easily, or is otherwise defective, at no additional cost to the Department.
- Where installation is covered by a referenced standard, perform installation in conformance with that standard, except as herein modified, and the Contractor must certify such. Also note additional requirements in other parts of this item.
- Unless otherwise noted, make up joints for gates and appurtenances using the same procedures as specified under the applicable type connecting pipe joint and install gates and other items in the proper position as recommended by the manufacturer. The Contractor will be responsible for verifying manufacturers' torquing requirements for the gates.

4.4.6.2. **Inspection, Testing, and Correction of Deficiencies. Before plant startup, inspect items for proper alignment, quiet operation, proper connection, and satisfactory performance.**

4.4.6.3. **Cleaning. Inspect items including gate interiors before line closure, for the presence of debris.**

4.5. **Ductless Split System Heat Pumps**. Provide split-system heat-pump unit consisting of separate evaporator-fan and compressor-condenser components. The split system heat pump must be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. The equipment must be constructed to the following standards.

4.5.1. **Action Submittals**. Submit the following for each type of product indicated.

- Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - Refrigeration piping system sizing and field configuration based upon actual equipment location and manufacturers specific requirements.
- Informational Submittals. Submit a sample of the special warranty.
- Closeout Submittals. Submit a copy of operational and maintenance data.

4.5.2. **Quality Assurance**.

- Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- ASHRAE Compliance:
  - Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
  - ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."
  - ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

4.5.3. **Special Warranty**. Provide Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period. The warranty should cover the following periods:

- For Compressor: Manufacturers extended warranty for 5 yr. from date of Substantial Completion.
- For Parts: 2 yr. from date of Substantial Completion.
- For Labor: 2 yr. from date of Substantial Completion.

4.5.4. **Wall-Mounted, Evaporator-Fan Components**.

- Cabinet: Enameled steel with removable panels on front and ends in color as shown in plans, and discharge drain pans with drain connection.
  - Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
  - Fan: Direct drive, centrifugal.
- Fan Motors:
  - Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 “Common Motor Requirements for HVAC Equipment.”
  - Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
  - Retain first subparagraph below if enclosure is not open-drip proof type. Retain second subparagraph for premium efficiency.
  - Enclosure Type: Totally enclosed, fan cooled.
  - NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
  - Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - Mount unit-mounted disconnect switches on exterior of unit.
  - If unique characteristics are required for motors in this Section, insert subparagraphs below.
- Condensate Drain Pans:
  - Fabricated with 1 percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
  - Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
  - Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
  - Minimum Connection Size: NPS 1.
- General Requirements for Air Filtration Section:
  - Comply with NFPA 90A.
  - Minimum MERV according to ASHRAE 52.2.
  - Filter-Holding Frames: Arranged for flat orientation, with access doors on both sides of unit. Filters must be removable from one side or lifted out from access plenum.
- Air-Cooled, Compressor-Condenser Components:
  - Casing: Steel, finished with baked enamel in color selected by Engineer, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
  - Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor must have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    - Compressor Type: Scroll.
    - Refrigerant: R-410A.

- Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

- Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
- Fan: Aluminum-propeller type, directly connected to motor.
- Motor: Permanently lubricated, with integral thermal-overload protection.
- Mounting Base: Polyethylene.
- Accessories:
  - Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
  - Compressor time delay.
  - 24-hr. time control of system stop and start.
  - Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
  - Fan-speed selection including auto setting.
  - Automatic-reset timer to prevent rapid cycling of compressor.
- Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

4.5.5. **Execution**.

4.5.5.1. **Installation and Demonstration**. **Install the split system heat pump level and plumb. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure. Install ground-mounted, compressor-condenser components on polyethylene mounting base.**

Field Quality Control. Perform tests and inspections. Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

4.5.5.2. **Tests and Inspections.**

- Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- Prepare test and inspection reports.

4.5.5.3. **Demonstration. Train Department's maintenance personnel to adjust, operate, and maintain units.**

4.6. **Sidewall Propeller Fans**. Provide wall-mounted propeller fan meeting the following requirements.

4.6.1. **Action Submittals**.

- Product Data: Provide the following or each type of product.
  - Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
  - Rated capacities, operating characteristics, and furnished specialties and accessories.
  - Certified fan performance curves with system operating conditions indicated.
  - Certified fan sound-power ratings.
  - Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - Material thickness and finishes, including color charts.

- Dampers, including housings, linkages, and operators.

■ Shop Drawings: Shop drawings should include the following.
- Include plans, elevations, sections, and attachment details.
- Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- Include diagrams for power, signal, and control wiring.
- Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

4.6.2. **Informational Submittals**.

■ Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.
■ Seismic Qualification Data: For fans, accessories, and components, from manufacturer.
- Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
- Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

■ Field quality-control reports.

4.6.3. **Closeout Submittals**. For centrifugal fans to include in normal operation, provide emergency operation, and maintenance manuals with replacement parts listing.

4.6.4. **Maintenance Material Submittals**. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

4.6.5. **Products**.

General:

■ Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
■ Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.
■ Belt Drives:
- Resiliently mounted to housing.
- Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
- Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
- Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
- Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

■ Accessories:
- Bird Screens: Removable, 1/2-in. mesh, aluminum or brass wire.
- Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
- Spark-resistant, all-aluminum wheel construction.

4.6.6. **Installation and Demonstration**.

■ Wall-mounted propeller fans must be installed using the following criteria:
- Install power ventilators level and plumb.

- Install units with clearances for service and maintenance.
- Label units according to requirements specified in this Item.

- Engage a factory-authorized service representative to perform startup service.
- Complete installation and startup checks in conformance with manufacturer's written instructions.
- Verify that shipping, blocking, and bracing are removed.
- Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
- Verify that cleaning and adjusting are complete.
- For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
- Adjust belt tension.
- Adjust damper linkages for proper damper operation.
- Verify lubrication for bearings and other moving parts.
- Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
- Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
- Shut unit down and reconnect automatic temperature-control operators.
- Remove and replace malfunctioning units and retest as specified above.
- Train Department's maintenance personnel to adjust, operate, and maintain centrifugal fans.

4.7. **Fixed Louvers**. Provide wall-mounted louver meeting the following requirements.

4.7.1. **Action Submittals**.

4.7.1.1. **Product Data. For each type of product, provide the following:**

- Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
- Rated capacities, operating characteristics, and furnished specialties and accessories.
- Material thickness and finishes, including color charts.

4.7.1.2. **Informational Submittals. Provide sample of special warranty.**

4.7.1.3. **Closeout Submittals. Provide operation and maintenance data.**

4.7.2. **Products–Louvers**. Provide fixed extruded aluminum louvers.

Horizontal, Continuous-Line, Drainable-Blade Louver, Extruded Aluminum: Drainable-blade louver with blade gutters (drains) in rear two-thirds of blades only.

- Louver depth: 6 in.
- Frame and Blade Nominal Thickness: Not less than 0.080 in. (2.03 mm).
- Mullion Type: Semi-recessed.
- Louver Performance Ratings:
- Free Area: Not less than 7.8 sq. ft. for 48-in. wide by 48-in. high louver.
- Point of Beginning Water Penetration: Not less than 850 fpm.
- Air Performance: Not more than 0.10-in. wg static pressure drop at 800-fpm free-area intake velocity.
- AMCA Seal: Mark units with AMCA Certified Ratings Seal.
- Finish: As selected by architect from manufacturer’s full range.

4.7.3. **Execution**.

4.7.3.1. **Examination. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the work. Proceed with installation only after unsatisfactory conditions have been corrected.**

4.7.3.2. **Preparation. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to the project site.**

4.7.3.3. **Installation. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.**

Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

Form closely fitted joints with exposed connections accurately located and secured.

Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with joint for sealants applied during louver installation as indicated on the plans and this specification.

4.7.3.4. **Adjusting and Cleaning. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.**

Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

4.8. **General Electrical Provisions**.

4.8.1. **General**. Perform electrical work in conformance with the applicable codes, standards, and ordinances including, but not limited to, National Fire Protection Association (NFPA), International Building Code (IBC), Underwriter's Laboratory (UL).

Employ a master electrician, licensed in the State of Texas to directly supervise the contractor forces.

Provide electrical submittals that are certified correct by the master electrician. Ensure persons performing electrical work have an appropriate electrical license.

Provide documentation that proves the contractor has a minimum of 5 yr. of experience and is qualified in this type of work and scope.

Install electrical service as shown on the plans and as required by the electrical utility company. Provide temporary electrical equipment, materials, and service necessary for constructing the pumping station, including any for dewatering.

Provide electricians to make necessary connections of the portable load banks to the load lugs of the generator or generator main breaker for the required generator set testing.

The Electrical Contractor must provide labor, materials, equipment, and services for a complete electrical system required for this contract including, but not limited to the following.

- Coordination of connections and providing conduits for work required for the electrical service.
- Electrical equipment and building grounding systems.
- Electrical connections complete to the equipment whether indicated on the plans or not.
- Motor starters and disconnects as required by the National Electrical Code. Provide the power wiring from panel to disconnect or starter and to motor or equipment. Wire line voltage controls carrying motor or equipment power.
- Support systems for electrical work.
- Cutting and patching as required for electrical work.
- Temporary electrical service if required during construction.
- Testing of electrical systems.
- Coordinate the work with Control System Supplier and provide related conduit and wiring for power and controls.
- Motor Control Center, automatic transfer switches, transformers, and required distribution equipment and associated feeders, and standby power system.
- Station lighting systems.
- All pump power, control, and alarm wiring.
- All wiring, conduit, and other equipment, whether shown on the plans or specifically mentioned in the specifications or not, to accomplish a fully functional electrical system.

4.8.2. **Submittals**. Include enough data in the submittals to make a thorough evaluation of features, construction, and performance.

Ensure materials, equipment, and fixtures completely satisfy specification requirements and are suitable for their intended use. Items of equipment submitted must include accessories and options recommended by the manufacturer for satisfactory, reliable, and safe operation in its designated location.

Manufacturer's model and catalog numbers change frequently and may not necessarily include specified or required features and may not ensure compatibility with supporting systems or intended application. Ensure that materials and equipment delivered to the jobsite are suitable for the intended application and the indicated connections. Review of shop drawings will not include review and verification of submitted catalog numbers or quantities required.

Ship or fabricate equipment in sections of suitable size for entering building and necessary arrangements for their installation must be made by the contractor.

Shop drawings and submittals must bear the General Contractor's review and approval stamp before submission to the Engineer.

Submit copies of shop drawings for electrical equipment custom made for this contract. Drawings must be revised as directed and resubmitted.

Submittals must show physical size and arrangement of equipment, wiring diagrams for equipment showing circuit devices, and elementary control diagrams in straight-line form for motor control equipment.

Cleary indicate in submittals which products are to be provided as part of this project.

Submit conduit layout proposed for the project for review and approval before installation.

4.8.3. **Materials**. Supply new materials listed by the Underwriters Laboratories, Inc., or locally approved national testing agency as conforming to standards in every case where such a standard has been established for a particular material in question. Equipment must be packaged in their original containers.

Furnish equipment or materials for any one system by the same manufacturer. Such items include conduit, wire, motor control center, wiring devices, etc.

Materials installed on exterior of buildings must be weathertight and of such design as intended for this purpose.

Install equipment in strict conformance with manufacturer's instructions for type, capacity, and suitability of each piece of equipment used. Install equipment in conformance with manufacturer's recommendations and meet conditions of manufacturer's standard warranty.

Protect work, materials, or equipment which are liable to cause injury during construction period. Securely cover or otherwise protect openings into any part of conduit system as well as associated fixtures, equipment, both before and after being set in place to prevent obstruction of conduit or injury due to carelessness or maliciously dropped tools or materials, grit, dirt, or any foreign matter. Assume responsibility for any damage until the work is installed and accepted. Cover conduit ends with capped bushings.

Furnish reinforced concrete housekeeping pads, a minimum 4-in. thick, or as noted, and extending 6 in., or as noted on plans, beyond equipment for free-standing electrical distribution equipment.

Provide accessories, equipment and connections required for complete installation, ready for continuous use.

Perform NETA Acceptance tests on each piece of equipment installed for this project. Tests labeled as optional are not required to be performed. Give timely notice of intention to test work to permit observation. Obtain the services of an independent NETA Member Testing Agency to perform any testing. The Testing Agency must test the entire electrical system in conformance with current procedures stated in Acceptance Testing Specifications published by the National Electric Testing Association. Furnish equipment necessary to conduct such test at no additional cost to the Department.

4.8.4. **Coordination with Other Trades**. Confer with other trades whose work might affect installation and arrange work in proper relation to that of others.

Where interferences occur, consult with the Engineer and other trades before installing work involved, to reach agreement as to exact location and level of work, and submit agreed upon layout for approval before starting this work.

Assume responsibility for arrangement of work, equipment, and maintenance of proper clearances for installation. Should work installed require modification to avoid interference, make such changes without additional cost.

If work is dependent for its proper execution on contiguous work not specified, examine such work and report in writing any defects therein or conditions rendering it unsuitable. Starting work without making a report will constitute an acceptance of work, and any subsequent defects in his work consequent will be the Contractor's responsibility.

4.8.5. **Permits**. Obtain permits, licenses and pay fees not otherwise identified in the specifications.

4.8.6. **Guarantee**. Unless otherwise specified, unconditionally guarantee for a period set forth in the General Conditions, but not less than 2 yr., materials, workmanship, and installation. During this period, adjust, repair, or replace at no cost to the Department any item of equipment or workmanship found to be defective. Assume responsibility for and pay for damages cause by or resulting from defects in workmanship.

4.9. **Electrical Testing**.

4.9.1. **Submittals**.

Qualification Data: For testing agency, submit company profile, listing of 10 similar projects performed in the last 2 yr. including contact information as references, and company and employee qualifications and certifications.

Final Equipment Test Report: After specified field inspection, testing and evaluation are completed, submit for approval the final equipment test report. Each equipment test report must be clearly labeled with whether the equipment passed or failed the test.

Project Work Schedule. Coordinate project work schedule with the Engineer and submit for approval before start of work.

4.9.2. **Quality Assurance**. The testing agency must be a single independent agency, with the experience and capability to conduct the required inspections and testing indicated that is a current full member company of the International Electrical Testing Association (NETA), and that is acceptable to the Authorities Having Jurisdiction (AHJ). Companies that are not a current full member company of NETA will not be permitted to bid on or perform this work. Persons performing inspection and testing functions must be permanently employed by the single independent agency. The testing agency's field supervisor must be a person currently certified by NETA to supervise on-site testing specified in these specifications.

The testing agency must have an up-to-date equipment calibration program. Use test equipment that is currently calibrated. Submit certifications of calibration for the equipment.

Before submitting the bid, the Contractor must visit the site and be thoroughly familiar with the existing conditions. Any errors, discrepancies, or missed items must be brought to the attention of the Engineer during the bidding process. No additional cost will be allowed for any discrepancy that could have been noticed at the site visit by the contractor.

4.9.3. **Project Conditions**. This work will be performed in an existing operational facility. Perform the work in conformance with the Department's schedule requirements to provide minimal impact to the building operations.

4.9.4. **Execution**. Inspection and Electrical Testing. Perform visual and mechanical inspections and electrical tests in conformance with applicable sections of the latest edition of the NETA Acceptance Testing Specifications (ATS) and in conformance with manufacturer recommendations for electrical equipment that is installed as part of this project. Optional tests referred to in the NETA ATS are not required. Return equipment to safe operational condition after inspections and electrical tests are completed.

Final Equipment Test Report. Prepare and submit for approval a written Final Equipment Test Report including the results from inspections, electrical testing, and power system data collection. The report must include, but not be limited to the items listed below. Submittals received without the information listed below will be rejected in their entirety and will not be reviewed:

- Cover Sheet: Typed, including project name, project location, testing agency name, and date.
- Summary of results: Typed, summarizing inspection results, test results and recommendations for any required corrective actions. Note: the equipment must be evaluated. Note equipment as being acceptable or requiring corrective action (with recommended corrective action noted).
- Letter from the testing agency stating that equipment included in the report has been tested and evaluated in conformance with applicable NETA recommendations.
- Equipment inspection and test data sheets including the following: Date of Test, Equipment designation, field inspection and test data including NETA required information, Clear Pass/Fail indication on each

sheet for each piece of equipment, recommended corrective action for any discrepancies, deficiencies or other as-found conditions requiring repair.

4.10. **Overcurrent Protective Devices Coordination and Arc Flash Study**. This section includes computer-based, fault-current and overcurrent protective device studies, and the setting of these devices. This section also includes completion of an arc flash study. The studies and reports must include the electrical system from the utility company service entrance down to and including proposed and existing to remain MCC's, panelboards, motors, automatic transfer switches, disconnect switches, generators, and any other major distribution system equipment. The studies and reports must address possible system switching configurations and alternate operating conditions that could result in maximum fault current conditions or worst-case incident energy levels.

4.10.1. **Submittals**.

- Provide product data for computer software program to be used for studies.
- Provide qualification data for coordination study specialists.
- Provide the following Action Submittals:
  - Coordination-study input data, including documentation from the utility company stating the available fault current at the service entrance.
  - Coordination-study report
  - Short Circuit evaluation report for equipment.
  - Settings report for adjustable trip devices.
  - Arc Flash study report.
  - Arc Flash warning labels for use in the field.

4.10.2. **Quality Assurance**. Use computer programs that are distributed nationally and are in wide use. Software algorithms must comply with requirements of standards and guides specified in this item. Manual calculations are not acceptable.

Coordination-Study Specialist Qualifications: Employ an organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices for at least 3 yr.. Submitted study must be stamped and signed by a professional engineer licensed in the state of Texas.

Comply with IEEE 399 for general study procedures. Comply with IEEE for short-circuit currents and coordination time intervals.

4.10.3. **Products**. Perform the studies using one of the following software packages: SKM or ETAP.

4.10.4. **Execution**.

4.10.4.1. **Examination. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Proceed with coordination study only after relevant equipment submittals have been assembled. Do not use overcurrent protective devices not submitted for approval with coordination. Studies must be based on equipment approved for use on this project. Perform site survey to obtain any additional information that is not shown on the drawings required to complete the specified studies. Coordinate with the local utility for site specific available fault-current data.**

4.10.4.2. **Fault-Current Study.**

- Source Impedance: Use utility company's fault-current contribution. Coordinate with the local utility for site specific fault current data.
- Study electrical distribution system from normal and alternate power source throughout electrical distribution system for project and use approved computer program to Eq values. Include studies of

system-switching configurations and alternate operations that could result in maximum fault conditions. Study and report must include the electrical system from the utility company service entrance down to and including MCC's, panelboards, motors, automatic transfer switches, disconnect switches, generator, and any other major distribution system equipment.

- Calculate momentary and interrupting duties on the basis of maximum available fault current.
- Calculations to verify interrupting ratings of overcurrent protective devices must comply with the following.
  - Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50
  - Low-Voltage Fuses: IEEE C37.46
  - Circuit Breakers: IEEEC37.13
  - Other Equipment: As Applicable
- Study Report: Enter calculated X/R ratios and interrupting fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2 Cycle), interrupting, and 30-cycle fault-current values for 3-phase, 2-phase, and phase to ground faults.
- Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault current momentary and interrupting duties.

4.10.4.3. **Coordination Study. Gather and tabulate the following input data to support coordination study.**

- Product data for overcurrent protective devices. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
- Impedance of utility service entrance
- Circuit breaker and fuse current ratings and types
- Transformer kVA, primary and secondary voltages, connection type, impedance, and X/R ratio
- Cables including conduit material, sizes of conductors, conductor material, conductor insulation, and length.
- Motor horsepower and code letter designation according to NEMA MG 1.
- Data sheets to supplement electrical distribution system diagram, cross referenced with tag numbers on diagram.

Perform a coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399. Provide recommended settings for adjustable overcurrent protective devices including, but not limited to the generator. Provide time current curve for the devices.

Comply with NFPA 70 for overcurrent protection of circuit elements and devices. Comply with IEEE 141 and IEEE 242 recommendations for fault currents and time intervals.

Transformer Primary Overcurrent Protective Devices must not operate in response to full load current or permissible transformer overloads in accordance with IEEE C57.96.

Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

Prepare a report indicating the following results of the coordination study:

- Tabular format of settings selected for Overcurrent Protective devices including device tag, relay current transformer ratio, circuit breaker sensor rating, long time, short time and instantaneous settings, and ground fault relay pickup and time delay settings.

- Coordination curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Curves must show device tag, voltage and current ratio for curves, three phase and single phase damage points for transformers, cable damage curves, transformer inrush points, maximum fault current cutoff point.
- Completed data sheet for setting overcurrent devices.

4.10.4.4. **Overcurrent Protective Device Setting. Engage a qualified testing agency to perform the device setting and to prepare test reports. After installing overcurrent protective devices and during energizing process of electrical distribution system, verify that the overcurrent protective devices meet parameters used in studies. Adjust devices to values listed in study results.**

4.10.4.5. **Arc Flash Study. Perform an arc flash study in conjunction with the previous specified fault current and protective device coordination study. Perform study in accordance with IEEE 1584.**

The study must be calculated using an approved computer software program. Pertinent data and the rational employed in developing the calculations must be incorporated into the introductory remarks of the study. The study must include the electrical system from the utility company service entrance down to and including MCCs, panelboards, motors, automatic transfer switches, disconnect switches, enclosed circuit breakers, generator, and other major distribution equipment.

Determine the following for each bus analyzed:

- Flash Hazard Protection Boundary
- Incident Energy Level
- Required Personal Protective Equipment (PPE) Category
- Type of Fire Rated Clothing
- Limited Approach Boundary
- Restricted Approach Boundary
- Prohibited Approach Boundary

Produce an Arch Flash warning label for each piece of electrical equipment that includes a specific equipment ID. Also include the system operating voltage and date of study. Labels must be printed in color on adhesive backed nylon labels. Sample label must be submitted for approval before installation. Labels must follow lates NFPA requirements.

Prepare a written report indicating the following results in tabular format:

- Flash Bus Name
- Protective Device Name
- Bus Operating Voltage
- Bus bolted fault current.
- Protective device bolted fault current
- Protective device arcing fault current
- Trip or delay time
- Breaker opening time
- Ground
- Equipment type
- Gap (mm)
- Arc Flash Boundary (in)
- Working Distance (in)
- Incident energy (cal/cm^2)
- Required Personal Protective Equipment

The electrical contractor must permanently affix the arc flash warning labels to each piece of electrical equipment including, but not limited to, motor control centers, panelboards, automatic transfer switches, disconnect switches, enclosed circuit breakers, and any other major distribution system equipment.

4.11. **Electric Materials and Methods**.

4.11.1. **Products**.

- Raceways and Fittings. For underground conduit, use PVC Schedule 80, heavy wall, UL listed. Provide a minimum 3 in. of clearance between conduits and a minimum 24 in. of cover or as noted on the plans. Use galvanized rigid metal conduit (RMC) for exposed conduit.
- Grounding System Devices and Equipment:
  - Ground rods must be 3/4 in. by 10 ft. copper clad steel.
  - Ground rod and cable connections underground: Use exothermic weld such as Cadweld or ThermOweld.
- Boxes:
  - Provide manufactured pull boxes that are one piece stamped galvanized steel, machine screw fasteners with ground bond screw, UL listed.
  - Direct burial handholes must be constructed of reinforced fiberglass with a cover rated for “heavy duty” traffic. Size must be as specified or as required by code, whichever one is larger. Provide by Quazite, Armorcast, or approved equal.
  - Conduit fittings must match conduit type.
  - Outlet, junction, and switch boxes must be cast, Type FS or FD. Cast boxes must be by Appleton, Hubbell, Killark, Thomas & Betts, or approved equal.
  - Group surface mounted devices in multi-gang cast box. The size will be governed by the intended use.
  - Exterior wall surfaces or otherwise exposed to weather must be cast FD boxes with threaded hubs and UL Listed.
  - Pull boxes should be constructed of code gauge galvanized sheet steel with screw cover.
  - Where installed below the operating level slab, in damp or wet locations, or outdoors, provide boxes made of Type 316 Stainless Steel, NEMA 4X.
- Conductors
  - Provide wire and cable that is UL listed, 600-Volt Type XHHW with 75-degree C rating.
  - Provide insulation in accordance with the latest edition of ICEA S-68-516, NEMA WC-8, UL 44, and IEEE 383.
  - Supply conductors that are soft annealed copper per ANSI/ASTM B-8, Class D, stranded.
  - The minimum allowable size of wire and cable is No. 12 AWG for power and No. 14AWG for control.
  - Use heat shrink tubing with sealant to seal any splices in wet wells.
  - Wire Connectors: For connections of one or more #10 AWG or smaller, use solderless twist-on connectors. The connectors must have an outer insulating shell manufactured from nylon material and must be formed with “S”-shaped fins to improve twisting. The spring insert must be a helical elongated coil formed from square spring steel to cause the spring to have “live action” and reduce turning friction. The connectors must be rated flame and heat retardant for up to 105°C maximum and be listed for UL 486. Conductors #8 AWG and larger must be terminated, spliced, or tapped wherever practicable with Thomas & Betts color keyed series 54000 tool applied compression connectors or approved equal.
  - Terminations: Supply Belleville type compression washers must be used when ambient temperature exceeds 30°C, T&B Series 60800, STS Industrial, or equal.

- Compression tools: Supply compression connectors made with manufacturers recommended tool incorporating a rachet release type mechanism to insure complete compression.
- Provide wire fastening products where wiring is required to be secured. Wire fastening products must include but not be limited to the following components: natural nylon cable ties, black (UV-resistant) cable ties, cable tie mounts, adhesive cable tie mounting pads, adhesive press clips, molded nylon clamps, molded polypropylene clamps, flat nylon clamps, and adhesive-mount adjustable clamps.
- Use pulling lubricants on raceway wiring. Pulling lubricants must be of a greaseless compound, non-corrosive, non-conductive, non-combustible, non-toxic, for use with PVC or steel raceways and safe for use on UL-listed wire insulation. The pulling lubricant must be Quick-Slip by Buchanan, Ideal, or approved equal.

■ Supporting Devices
- Secure materials to the structure by inserts cast in concrete, expansion anchors in concrete block, machine screws or bolts on metal surfaces. Hardware must be Type 316 stainless steel. Provide hangars as follows:
  - Channel: Type 316 stainless steel by Kindorf, Unistrut, Globe Strut, or B-Line.
  - Channel Fittings: Type 316 stainless steel by Kindorf, Unistrut, or B-Line.
  - Conduit Hangars: Type 316 stainless steel clevis type by Unistrut, Kindorf, or Grinnell.
  - Wall Anchors: Expansion bolt, toggle bolt, or other approved structural anchor. Hardware must be Type 316 stainless steel.
- For electrical materials and components secured to joists, fasten to the top member of the joist.

4.11.2. **Execution**.

4.11.2.1. **Preparation. Check door swings and clearances with equipment, cabinets, appliances, and coordinate with the plans before performing work.**

4.11.2.2. **Installation. Install exposed wiring and conduit in a neat and workmanlike manner with runs plumb and parallel to walls. Avoid bends and offsets where possible, but where necessary, make with an approved conduit bending machine. Conduit or tubing which has been crushed or deformed in any way or has begun to rust must not be installed. Use expansion bolts to secure equipment, conduit, or devices. Support conduit or tubing on approved types of stainless-steel wall brackets, ceiling trapeze, or pipe straps, and secured by means of expansion bolts in concrete or brick. Do not use nails used as a means of fastening surface boxes or conduits. Install conduit or tubing to insure against trouble from collection of trapped condensation and arrange runs on conduit to be devoid of traps wherever possible.**

Raceways must meet requirements of the National Electrical Code and local codes.

Use liquid-tight flexible metal conduit for connections to motors and other electrical equipment subject to movement or vibration. Maximum length must not exceed 3 ft.

Wire and cable must be continuous without splicing from load to source to supply. Only perform splicing after obtaining written approval.

Wire and cable, including grounds, must be run in conduit unless written permission is obtained.

Provide clamps made of stainless steel. Multiple runs of conduit must be supported on metal channel with conduit clamps. Trapezes must be metal channel with conduit clamps.

Sleeve penetrations through concrete walls, floors, and footings, both interior and exterior and caulk with grout or plastic compound to provide watertight seal.

Bends must be kept in conformance with minimum recommended by manufacturer. Cables must be paralleled on reels and be pulled directly into raceway from the coils or reels on which they are received. Do not lay cable on the ground.

Use pulling lubricants on raceway wiring. Install wire and cable only after raceways are free of obstruction and clean. Wire must be color coded. Tag wiring with Brady "Quick" labels at terminations with each individual wire with a unique identifying number. Wiring in panelboards and terminal cabinets must be neatly trained and served.

Install empty conduits complete with a nylon pull cord.

4.12. **Service Distribution**. Install complete electrical distribution system, underground conduits, and trenches, and backfill as required. Perform infrared testing of motor control center, panelboards, VFD's, and automatic transfer switch.

4.12.1. **Submittals**. Submit cut sheets on items of electrical equipment. Include panelboards, switches, wiring, receptacles, motor starters, disconnect switches, wiring devices, cover plates, nameplates, distribution equipment and overcurrent devices.

4.12.2. **Infrared Testing**. Employ an independent certified testing laboratory to inspect and test the motor control center, panelboards, and automatic transfer switches. Perform infrared tests to determine that the terminations are tightened to proper torques and that no part of the equipment is overheating beyond normal operating conditions. Perform this test twice, once at 1 week after substantial completion of the project.

4.12.3. **Products**.

4.12.3.1. **Lighting Panelboard. Provide the lighting panel with circuit breakers that have the capacity indicated on the drawings. Locate the top operating handle a maximum of 6.5 ft. above the finished floor. Provide typed panel directory in panel. Incorporate panel as an integral part of the Motor Control Center.**

4.12.3.2. **Circuit Breakers. Provide Thermal magnetic type circuit breakers, tripping free of handle. Handle must have three distinctive positions: 'OFF,' 'ON, and "TRIPPED. Provide solid state trip units where indicated on plans.**

4.12.3.3. **Thermal-Manual Motor Starters. Unless otherwise indicated on the drawings, provide thermal-manual motor starters that are line-voltage type with thermal over-load protection and red "run" pilot light. Thermal manual starters must be quick make and break, toggle operated, trip free, and must be provided with lock off handle guard. Where required for automatic operation by a remote pilot device, thermal-manual motor starters must be provided with a "hand-off-automatic" selector switch, in addition to the "on-reset-off" toggle switch. Thermal-manual motor starters must be wall mounted with stainless steel plates. Thermal manual motor starters must be rated 30 amps, Square D Class 2510, Eaton, or approved equal.**

4.12.3.4. **Magnetic Motor Starters. Provide magnetic motor starters that are full voltage; horsepower rated, across the line starting with 120V control. Provide 120V control transformer with fused secondary. Motor starters must be NEMA rated. Provide green "run" and red "stop" pilot lights mounted in cover. Pilot lights must be provided with factory-finished legend plates indicating "stop," "run," etc. Pilot lights must be provided with interlocks controlled by the starter operating coil.**

Provide Solid State Overload Relays with the following features:

- Switch or dial selectable for motor running overload protection,
- Sensors in each phase, and
- Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

Provide reset button, run time meter, start counter, and Hand-Off-Automatic switch for each starter. Items must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the enclosure.

For each starter, provide a minimum of 4 auxiliary spare contacts, 2 N.O. and 2 N.C., for interlocking and automatic operation. Contacts must also be convertible from N.O. to N.C.

All three phase starters must have phase monitors that must automatically shut down the load during single phase conditions.

4.12.4. **Wiring Methods**. Branch circuit wiring for switches, lighting, and receptacles must be exposed on walls and ceilings. Wiring must be supported in conformance with provisions in the National Electrical Code and local code requirements and must use approved fasteners and clamps. Conduits secured to walls must be fastened to wall studs where spacing permits. Rigidly secure conduits and clamps ensure they are free of obstruction which may cause injuries.

All conductors must be color coded:

- 480/277V System: Brown, Orange, Yellow
- 208/120V System: Black, Red, Blue
- Neutral: White
- Ground: Green

No. 8 AWG or larger conductors must have NEC required color coding as:

- Solid color compound or solid color coating
- Colored, pressure sensitive plastic tape. Tape must be applied in half overlapping turns for a minimum of 3 in. for terminal points, and in junction boxes, pull boxes, troughs, manholes, and handholes. Tape must be 3/4-in. wide with colors as specified above. The last two laps of tape must be applied with no tension to prevent possible unwinding.

4.12.5. **Wiring Devices**. Light Switches: Provide switches that extra hard use, commercial premium specification grade and comply with Federal Specification W-S 896B and rated 20 amps and voltage as dictated by the system. They must be approved for control motors up to 80 percent of the switch rating and must be quiet AC type. Use single pole, double pole, three way or four way switches, as shown.

Receptacles: Receptacles must be extra hard use, commercial premium specification grade, two pole, three wire, and straight blade type and must comply with Federal Specification W-C 596E with a rating of 20 amperes for single receptacle circuits or as indicated on the drawings.

All outlets and switches must be brown in color.

Ground Fault Interrupter devices must be duplex receptacle type and must comply with UL standard 943, Class A. They must be no more than one and one-eighth in. deep with standard terminal screw connections and feed-through capability rated at 20 Amps.

All receptacles must have weatherproof boxes with while-in-use covers. Switch and other device plates must be stainless steel. Depth must be suitable for sump-pump plug.

Emergency stop push buttons must be snap type maintained contact mushroom style switches. Allen Bradley 800 series, Square D, s or approved equal.

4.12.6. **Connections to Mechanical Equipment**. Carefully make a note other equipment requiring electrical power to be furnished to fully understand wiring and motor starting requirements.

Furnish and install an enclosed disconnect switch and motor starter for each motor installed unless specifically indicated as furnished with the equipment.

Furnish and install power wiring for motors complete from Motor Control Center or panelboard, through motor starter, to motor terminations.

Provide disconnect switches where shown on the plans or as required by the NEC, fused or unfused as required, Heavy Duty and must be Square D Class 3110, Eaton, or approved equal. Any switch installed outdoors or below grade level in the pump station must be rated NEMA 4X and must be Type 316 stainless steel. Provide option to allow locking in open and closed position.

4.12.7. **Fuses**. Coordinate fuse ratings with utilization equipment limitations of maximum fuse size. Furnish and install three extra fuses of each type and rating used.

Subject to compliance with requirements, supply fuses from one of the following manufacturers:

- Cooper Bussman,
- Feral Shawmut, or
- Littlefuse.

Cartridge fuses: Provide NEMA FU1, non-renewable cartridge fuses, class and current rating indicated; voltage rating consistent with circuit rating.

Fuse Applications:

- Motor Branch Circuits: Class RK1, time delay
- Other Branch Circuits: Class RK1, time delay

Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

Install labels indicating fuse replacement information on inside door of each fused switch.

4.12.8. **Motor Starters and Controls**. Install items in conformance with manufacturer's instructions. Provide interlocks, contacts, pilot lights, and Hand-Off-Auto switches for starters. Provide starters, push buttons, etc. Mount motor starters on wall and install suitable stainless-steel enclosures and cover plates. Set overload devices to suit motors provided. Connect motors with maximum 3 ft. length of liquid tight flexible metal conduit at motor connection.

4.12.9. **Grounding**. Provide ground bond to cold water services and to ground rods. Bond non-current carrying metallic parts of equipment, mechanical systems, and building steel. Neutral conductor at main switches must be grounded. Ground bus must not be less than size required by National Electrical Code and any local codes. Grounding system must be complete and installed in conformance with local jurisdictions requirements. Ground rods must be copper clad steel, driven as indicated. Where soil conditions are poor, notify the engineer so that supplemental grounding may be considered. Ground and bond piping systems and building steel within building as required by the NEC.

Temporary Service. Make the necessary arrangements and provide temporary electric service and lighting required during the entire construction period. The metered costs of electricity used must be borne by the contractor upon final acceptance. The electric service must be of enough capacity and characteristics to supply the proper current for the various types of construction tools, motors, welding machines, lights, heating plant, pumps, and other work required. Provide necessary temporary wiring, panelboards, outlets, switches, lamps, fuses, controls, and accessories. Exact location of temporary service delivery point must be agreed upon by utility company and Department. Contractor's installation of temporary service must comply with applicable codes and regulations and must include ground fault interrupters.

Power Company Coordination. Provide site facilities per power company's requirements. Contractor must not do any rough-in of empty conduits, transformer pads, meter sockets, etc. until the utility company has produced engineered drawings indicating exact locations and conduits required.

4.12.10. **Execution and Installation**. In general, install switches and receptacles in locations shown on contract drawings. Conduit and wiring for switches and receptacles must be exposed on walls. Study general building plans in relation to space surrounding each device in order that intended work may accommodate other specific work and must make minor adjustments as needed. Install boxes in a rigid and satisfactory manner. Support boxes independent of raceways. Adjacent wall mounted wiring devices, room thermostats, or other equipment must be coordinated so located either at the same elevation or in line, one above the other. Install conduit, outlets and equipment to clear beams or obstructions. Do not cut into or reduce the size of any load-carrying member without the approval of the Engineer. Obtain permission of Engineer before cutting any existing structure concrete walls or floors. Check drawings and work of others to prevent interference. Perform deviations of work to avoid obstructions as determined without additional cost.

Ground equipment in conformance with the National Electrical Code requirements and utility company requirements.

Use the following mounting heights, unless otherwise specified:

- Receptacles – 48 in. above finished floor
- Wall Switches – 48 in. above finished floor

All wiring devices must be wired using the screw terminals. Push connections are not acceptable.

Support pull boxes and junction boxes in ceiling from structure and not from raceways or ceiling suspension system.

Use locknuts and insulating bushings at rigid conduit ends at junction boxes, pull boxes, panel, starters, disconnect switches, and other boxes.

Protect conduit openings and do not pull wire until work which would damage wire has been completed near ends of conduit. Furnish empty raceways with nylon pull strings.

Bend conduits with a conduit bender, where bends are necessary.

When cutting conduit, square ends, thread, ream, and clean.

Use gasketed covers and threaded raceway hubs for exterior raceway connections. Use vandal resistant hardware at outdoor locations.

Label safety switches, disconnect switches, motor starters, and other equipment with engraved laminated plastic tags, not smaller than 3/8" high, indicating function served. Letters must not be smaller than ¼" high and must be black on white background. Submit proposed designations and sample for approval.

4.13. **Grounding**. Ground secondary service neutrals at the supply side of the secondary disconnecting means and at the related transformers. Ground metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in proximity with electrical circuits for personnel safety and to provide a low impedance path for possible ground fault currents.

4.13.1. **Submittals**. Submit catalog cut sheets and descriptive literature for approval in accordance with Article 3, Operations and Maintenance Manuals. Include enough information clearly presented to determine compliance with drawings and specifications.

- Submittals: Ground Rods, connectors, and exothermic welding system

- Submit and certify test reports from the NETA approved testing agency of ground resistance to the engineer. Reports must indicate date, time, temperature, and equipment used for ground resistance testing, by manufacturer and model number.
- Test grounding systems in conformance with NETA standards and summarize in the report.

4.13.2. **Products**. Ground wires must be UL and NEC approved types, copper, with green insulation, except where otherwise shown on the drawings or specified.

4.13.3. **Execution**. Connect the secondary service neutral to the ground bus in the service equipment. Provide a ground loop with a minimum of three ground rods and foundation ground connection and connect to the service equipment ground bus.

4.13.3.1. **Service Entrance Motor Control Center. Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors. Connect the various feeder green grounding conductors to the ground bus in the enclosure with suitable crimped pressure connectors. Connect the grounding electrode conductor to the ground bus. Connect the neutral to the ground bus. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and ground wire to the ground bus.**

4.13.3.2. **Conduit Systems. Ground metallic conduit systems. Conduit systems must contain a grounding conductor. Metallic conduit provided for mechanical protection and containing only a grounding conductor must be bonded to that conductor at the entrance and exit from the conduit. Use grounding bushings for feeder conduits attached through concentric knockouts regardless of system voltage.**

4.13.3.3. **Feeders and Branch Circuits. Install green grounding conductors with feeders and branch circuits.**

4.13.3.4. **Boxes, Cabinets, Enclosures, and Panelboards. Bond the grounding wires to each pull box, junction box, outlet box, cabinets, and other enclosures through which the ground wires pass. Provide lugs in each box and enclosure for ground wire termination. Provide ground bars in panelboards, bolted to the housing, with enough lugs for terminating the ground wires.**

4.13.3.5. **Motors and Starters. Provide lugs in motor terminal box and starter housing for ground wire termination. Make ground wire connections to ground bus in motor control center.**

4.13.3.6. **Receptacles. Provide receptacles with a ground wire from green ground terminal to the outlet box ground screw, regardless of type, except for isolated ground devices.**

4.13.3.7. **Lighting Fixtures. Fixtures must have a green ground wire included with the power wires.**

4.13.3.8. **Electrical Appliances, Pipe, and Equipment. Provide fixed electrical appliances and equipment with a ground lug installed for termination of the green ground conductor. Bond the water main with #6AWG conductors.**

4.13.3.9. **Ground Resistance. The grounding system must be provided and tested in the presence of Department to ensure that the ground resistance does not exceed 5 ohms. One week notice must be given before the scheduled test and the Engineer must also have the option to witness the testing. Service at power company interface points must comply with the power company ground resistance requirements. Necessary modifications to the ground electrodes including driving of additional electrodes for compliance must be installed at no additional cost to the Department.**

4.13.3.10. **Ground Rod Installation. Drive each rod vertically at least 10 ft. deep and bury minimum of 30 in. below finished grade. The ground rods must be located a minimum of 10 ft. apart from each other. Submit a proposed location of the ground rods as part of the conduit layout plan for approval. Where required to obtain the specified ground resistance, install multiple rods, but in no case less than**

three rods. For ground rods, make the connections by the exothermic process to form solid metal joints.

4.14. **Low Voltage Transformers**. This section includes dry-type transformers rated 600V and less.

4.14.1. **Submittals**. Provide product data including rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices, features, and performance for each type and size of transformer indicated.

4.14.2. **Quality Assurance**.

Testing Agency Qualifications: Employ an independent agency, with the experience and experience and capability to conduct the testing indicated, that is a full member company of NETA, and is acceptable to authorities with jurisdiction.

Source Limitation: Obtain each transformer type through one source from a single manufacturer.

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing a testing agency acceptable to authorities with jurisdiction and marked for intended use.

Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

4.14.3. **Products**.

4.14.3.1. **Available manufacturers. Subject to compliance with requirements, offering products that may be incorporated into the work include, but are not limited to, the following:**

- Square D; Schneider Electric
- Eaton
- G. E. Company

4.14.3.2. **General Transformer Requirements.**

- Description: Factory-assembled and tested, air cooled units for 60-Hz service.
- Cores: Grain: oriented, non-aging silicon steel.
- Coils: Continuous windings without splices except for taps.
  - Internal Coil Connections: Brazed or Pressure type
  - Coil Material: Copper

4.14.3.3. **Distribution Transformers.**

- Comply with NEMA ST 20 and list and label as complying with UL 1561
- Cores: One leg per phase
- Enclosure: NEMA 250, Type 2 unless noted otherwise
- Core and coil must be encapsulated within resin compound, sealing out moisture and air
- Tap for transformers 7.5kVA to 24 kVA: one 5% tap above and one 5% tap below normal full capacity.
- Taps for transformers 25kVA and larger: Two 2.5% taps above and two 2.5% taps below normal full load capacity.
- Insulation class: 220 degree C, UL component recognized insulation system with a maximum of 115 degree C rise above 40 degree C ambient temperature. The 115 degree C rise transformers must be capable of carrying a 15% continuous overload without exceeding a 150 degree C temperature rise.
- Transformers 15 kVA and larger: comply with NEMA TP 1, Class 1 efficiency levels and tested according to NEMA TP 2.
- Electrostatic shielding: Each winding must have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

4.14.4. **Execution**.

4.14.4.1. **Examination. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers are installed. Verify that ground connections are in place and requirements of "Grounding" in this item have been met. Maximum ground resistance must be 5 ohms at location of transformer. Proceed with installation only after unsatisfactory conditions have been corrected.**

4.14.4.2. **Connections. TESTING, TRAINING, DOCUMENTATION, FINAL ACCEPTANCE, AND WARRANTY Field Quality Control. Engage a qualified testing agency to perform tests and inspections and prepare test reports. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters. Remove and replace units that do not pass tests or inspections and retest as specified above.**

Infrared Scanning: Two months after Substantial Completion, perform infrared scan of transformer connections. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

4.14.4.3. **Adjusting. Record transformer secondary voltage at each unit for at least 48 hurs of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.**

Output Settings Report: Prepare a written report recording output voltages and tap settings.

4.14.4.4. **Cleaning. Vacuum dirt and debris; do not use compressed air to assist in cleaning.**

4.15. **Lighting**. Provide lighting including furnishing, storing, installing, and connecting fixtures, complete for continuous satisfactory operation. Included is furnishing lamps, mounting brackets, stems, escutcheons, frames, and trim required to match surrounding surface.

4.15.1. **Submittals**. Contractor must verify ceiling types and coordinate trip and mounting hardware before submission of fixtures and must have final responsibility to insure proper compatibility of fixture type with ceiling system.

Manufacturer's model and catalog numbers change frequently and may not necessarily include features or options as specified herein or required for complete installation. In particular, catalog number may only indicate type and series of required fixture. When specified types, finishes, features, options, and accessories conflict with a given model number, former must govern.

Submit cut sheets for fixtures furnished. Submittals will not be checked for proper or complete catalog numbers.

Under base bid, furnish fixtures and equipment specified or named equals. Where no named equal is given and only "Or approved equal" is noted, Contractor may at his option use alternates of his selection. However, such alternate must conform to the specified fixture's construction, performance, and catalog features and must have a similar aesthetic appearance. Failure to conform will result in rejection of item.

4.15.2. **Products**. Provide products meeting the following requirements.

- Color temperature: 4000K

- Rated Lamp Life: 50,000 hr. minimum
- Light fixtures must bear label of Underwriters' Laboratories, Inc. and must be suitable for intended location. Fixtures must be labeled indicating suitability for damp or wet locations where required.
- Each fixture must be supplied with necessary straps, supports, or hangers, or other miscellaneous materials and devices to install them in a satisfactory manner to conform to architectural treatment and finishes in area in which they are installed.

All fixtures furnished must be standard manufacturer's cataloged and stocked fixtures. Specially fabricated fixtures, unless so specified, will not be accepted. Replacement parts and lenses must be readily available from manufacturer. Fixture voltages must be as shown to be connected on drawings. Refer to plans for lighting fixture schedule.

4.15.3. **Execution**.

4.15.3.1. **Installation. Support fixtures from structure above, provide rigid hangers or framing to support units.**

Coordinate fixture locations with ceiling framing and equipment locations. Align continuous row fixtures in uniform rows. Furnish metal channels to achieve alignment, if required. Securely support fixtures with approved hangers. Such hangers must be set in perfect alignment and elevation.

Outlet mounted fixtures must be mounted directly to mounting ears of outlet box or to fixture studs as required by selected fixtures. Furnish structural supports for heavy fixtures.

Carefully place splices in outlet boxes or wiring gutters with no crowding in a neat and orderly manner.

4.15.3.2. **Guarantee. Unless otherwise specified, unconditionally guarantee for period as set forth in General Conditions, material, equipment, workmanship, and installation. During this period, adjust, repair, or replace any item or equipment or workmanship found to be defective, at no cost to the Department.**

LED fixtures must be guaranteed for a minimum of 5 yr. after Substantial Completion.

4.16. **Automatic Transfer Switch**. Provide solid state logic automatic transfer switch by Schneider Electric, Eaton, or Russel Electric. Mount the switch as part of the MCC as shown on the plans and must be delayed transition type with center-off position between the two available sources.

4.16.1. **Submittals**. Submittal must include specification sheets showing standard and optional accessories to be supplied; schematic wiring diagrams; dimension drawings; and interconnection diagrams identifying by terminal number each required interconnection between the generator set, pump control panel, and transfer switch.

4.16.2. **Switch Operation**. Provide a four-pole switch with switched neutral.

4.16.3. **Control Panel**. Provide an automatic transfer switch three-phase control panel that uses solid-state sensing for automatic, positive operation. Provide the following:

- The normal or preferred source voltage across live lines must be monitored line-to-line. Close differential voltage sensing must be provided. The pickup voltage must be adjustable from 75% to 100% of nominal. The dropout voltage must be adjustable from 70% to 98% of the pickup value. The transfer to emergency or secondary power will be initiated upon reduction of normal/preferred source to 85% of nominal voltage and retransfer to normal/preferred must occur when source restores to 95% of nominal.
- A test switch to momentarily simulate normal/preferred source failure.
- Harnessing between transfer switch and control panel must have built-in disconnect for routine maintenance.

The moveable parts of the operating mechanism must remain in positive mechanical contact with the main contacts during the transfer operation without the use of separate mechanical interlocks. Automatic operation of the switch must not require power from any source other than the line-to-line voltage of the source to which the switch is transferring.

4.16.4. **Products**.

4.16.4.1. **Equipment. The automatic transfer switch must consist of a power transfer module and a control module, interconnected to provide complete automatic operation. The automatic transfer switch must be mechanically held and electrically operated by a single solenoid mechanism energized from the source to which the lead is to be transferred. Supply a switch rated for continuous duty and be inherently double throw. The automatic transfer switch must be suitable for use with emergency sources, such as engine or turbine generator source, or with another utility source.**

Provide main contacts made of silver composition. The operating transfer time in either direction must not exceed 1/6th of a second.

Contacts, coils, springs, and control elements must be conveniently removable from the front of the transfer switch without major disassembly or disconnection of power conductors.

Supply a control module with a protective cover and mount separately from the transfer switch for ease of maintenance. Sensing and control logic must be solid state and mounted on plug-in printed circuit boards. Printed circuit boards must be keyed to prevent incorrect installation. Interfacing relays must be industrial control grade, plug in type with dust covers and locking clips.

Automatic transfer switches utilizing components of molded case circuit breakers, contactors, or parts thereof which have not been intended for continuous duty or repetitive load transfer switching are not acceptable.

The automatic transfer switch must conform to the requirements of NEMA standard ICS 2-447 and UL-1008. Automatic transfer switch must be UL listed for use in emergency systems in accordance with Articles 517 and 700 of the National Electrical Code and rated in Amperes for total system transfer including control of motors, electric heating, and LED fixtures.

The automatic transfer switch must be rated to withstand the manufacturer's standard rating for symmetrical amperes short circuit current based on the coordinated circuit breaker.

The automatic transfer switch must be mounted as part of the motor control center as indicated on the plans.

The automatic transfer switch must be delayed transition.

4.16.4.2. **Accessories.**

- Switches must include a time delay on transfer from normal/preferred to emergency/secondary, field adjustable from 6 to 60 seconds.
- Switches must be a time delayed transition type with a center position available between the two available source positions.
- Switches must include a time delay on retransfer from emergency/secondary to normal/preferred, field adjustable from 1 to 30 minutes. The time delay must be automatically bypassed if the emergency/secondary source fails and the normal/preferred source is available.
- The switches must include voltage and frequency sensing of the emergency/secondary source and must be factory set to allow transfer to emergency/secondary when that source is at approximate rated voltage and frequency.

- Contacts rated 10 Amps, 32 Volts DC which close when the normal source fails must be provided to initiate engine starting, where applicable. Provide signals between automatic transfer switch, generator, and pump control panel as shown on the drawings.
- Switches must include a time delay to ignore momentary outages. It must delay closing of the engine start contacts for an adjustable time from 0.5 to 6 seconds.
- Switches must include a time delay for engine cool down, adjustable from 0 to 15 minutes.
- One auxiliary contact closed when the switch is in the normal/preferred position and one closed when the switch is in the emergency/secondary position must be provided. Contacts must be rated 10 amps, 480 volts AC. Provide signals to the pump control panel as shown on the drawings.
- Two pilot lights to indicate switch in normal/preferred or emergency/secondary position must be installed in the door of the enclosure.
- Two contacts must be provided which close when the generator runs and opens when the generator stops. They must be rated 10 amps, 120 volts. Provide signals to the pump control panel as shown on the drawings.
- A plant exerciser that is (7 day, time adjustable more than 30 min.) field adjustable for exercising the generator on 30 min. increments must be provided. Provide a selector switch for load or lo load operation.
- Outputs must be provided to the generator for control and to the pump control panel form monitoring and alarm as indicated on the drawings.
- Switches must be provided with auxiliary contacts to indicate normal utility power failure.

4.16.5. **Execution**.

4.16.5.1. **Testing. Perform the following tests.**

- Certified laboratory test data on a switch of the same design and rating must be provided to confirm the following switch abilities:
- Overload and endurance per Tables 21.2 and 23.2 of UL-1008 when enclosed according to Paragraph 1.6
- Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits of the insulation in contact with current carrying parts.
- Withstand current tests per Paragraph 25 of UL-1008 for 5000A rms symmetrical, at 480V and X/R ratio of 6.6.
- No welding of contacts. Transfer switch must be operable to alternate source after they withstand current tests.
- Test remote monitoring and alarm signals to and from the sources and the pump control panel.

All production units should be subjected to the following factory tests.

Test the complete automatic transfer switch to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency, and time delay settings are in compliance with the specification requirements.

The complete automatic transfer switch must be subjected to a dielectric strength test per NEMA Standard ICS 1-109.05.

The control panel must meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 and the impulse withstand voltage test in accordance with the proposed NEMA Standard ICS 1-109.

An authorized representative of the switch manufacturer and Engineer must attend startup activities to assist the contractor with installation, testing, and certifying the system.

4.16.5.2. **Certification. The manufacturer must provide a letter certifying compliance with the requirements of the transfer switch specifications. The certification must identify equipment by serial number and must include no exceptions to the specifications, except those stipulated with the submittal.**

4.16.5.3. **Guarantee. Each transfer switch must be provided with an operator's manual providing installation and operating instructions.**

4.17. **Standby Generator**. Provide a standby power generator system in conformance with the plans and specifications. Perform work in conformance with NFPA, NEMA, and IEEE standards.

4.17.1. **Quality Assurance**. The standby generator system, including engineer-generator set, generator, and generator controls, must be furnished by a single manufacturer who has been regularly engaged in the production of engine generator sets, generators, engine auxiliaries, and controls for a minimum of 10 yr. The manufacturer must have a local representative who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.

The generator set and controls must provide a completely automatic unattended operation for the duration of a loss of normal utility power. Provide controls that are the standard of the manufacturer.

The generator set manufacturer must assume full responsibility for correct operation of the entire standby power generator system, including the fuel distribution system.

Perform the following final production tests:

- Test each generator set under varying loads with guards and exhaust system in place before shipment of the standby power generator system.
- Final production tests must include Single-step load pickup, transient and steady state governing, safety shutdown device testing, voltage regulation, rated power, maximum power.
- Test the specified generators are to be used to start and run large motors.

The standby power generator system must be guaranteed in writing for defects in materials and workmanship for a period of 5 yr. from the date of Substantial Completion. Multiple warranties for individual components such as engine, alternator, and controls, will not be acceptable. The warranty must be comprehensive, and must include parts, labor, travel, and other miscellaneous expenses.

In addition to the stipulated guarantee, the generator manufacturer, or his approved agent, must provide a comprehensive service contract for a period of 5 yr. from the date of Substantial Completion. The service contract must cover necessary parts, labor, travel, and other services required to keep the generator in complete working order at times. The only items excluded from the service contract must be fuel and regular oil changes and lubrication.

4.17.2. **Submittals**. Provide the following submittals:

- Shop drawings showing fabrication, assembly, foundation, and installation.
- Catalog data and detailed specification sheets for standard and optional accessories to be supplied.
- Wiring diagrams and electrical schematics indicating operation, controls, and power supply.
- Operation and maintenance manual for standby power generator system.
- Certified copies of manufacturer's final production test results.

4.17.3. **Materials**. Provide equipment specified for the standby power generator system manufactured by Caterpillar, Cummins, or approved equal. Generator must have a rating as indicated herein or on the plans. Basis of

design for generator is Caterpillar. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the contractor with no extra cost to the Department.

4.17.3.1. **Engine-Generator Set. Mount the engine-generator set on a structural steel base to maintain proper alignment between components. The structural steel base must incorporate vibration isolators of the type and quantity recommended by the manufacturer to obtain a minimum of 95% vibration attenuation.**

Engine must be liquid cooled for use with natural gas.

Furnish an engine with the following accessories:

- Replaceable full-flow oil filters and oil drain valve with hose extension. Provide 2 spares of each filter.
- Replaceable dry element air cleaner. Provide 2 spares of each filter.
- Replaceable fuel filters. Provide 2 spares of each filter.
- Provide 2 spares of each type of belt.
- Electric starting systems, including starting motor, batteries, battery charger, cables, and battery rack. Provide float/equalize battery charger. Batteries must be provided with cold cranking amp capacity 25 percent higher than the manufacturer's standard for the unit provided.
- Batteries must be lead-acid or nickel cadmium type and battery charger must include temperature compensation feature with voltmeter and ammeter to indicate battery charging voltage and current.
- Safety devices to protect the engine against high and low coolant temperature, low lubricating oil pressure, over-speeding, and over-cranking.
- Engine-mounted, thermostatically controlled jacket water heater rated as required. The heater must be disconnected by an oil pressure switch mounted on the engine when the engine starts.
- Unit mounted radiator with engine driven fan.
- Instrument panel with lubricating oil pressure gauge, water temperature gauge, and battery charging ammeter.
- Hospital type (critical) exhaust silencer, sized as directed by the generator set manufacturer. Provide thermal insulation jacket. Wrap silencers and the straight pipe section from the silencer to the wall thimble must be wrapped with high temperature-flexible insulation which conforms to Military Specification MIL-I-16411-E, Type II. Insulation must be Type E Fiberglass Insulation designed for use in insulating high temperature equipment as manufactured by Advanced Thermal Products, Inc. or equal. Insulation must be flexible, lightweight and must not compact under vibration. Insulation must be manufactured from chopped glass fibers and must be free from resinous binders. Insulation must be installed in conformance with the manufacturer's recommendations.
- All necessary piping, stainless steel flexible exhaust tubing, fittings, mounting hardware, flapper type exhaust cap, and other equipment necessary to complete the exhaust system must be provided. Exhaust pipe opening through generator enclosure or building must be made weatherproof, and vermin-proof. Provide manufacturer approved wall thimble.
- The generator set supplier must furnish lubricating oil to fill the crankcase and 50 percent ethylene glycol antifreeze solution to fill the engine cooling system.
- Unit mounted main circuit breaker.

4.17.3.2. **Generator. Provide an alternator that is salient-pole, brushless, 12-lead reconnectable, of 2/3 pitch to eliminate the third harmonic, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed for smooth voltage waveform. The insulation must meet the NEMA standard (MGI-22.40 and 16.40) for Class H and be vacuum, impregnated with epoxy varnish to be fungus resistant per MIL 1-24092. Temperature rise of rotor and stator must be limited to NEMA Class F. The excitation system must be brushless construction controlled by a solid-state voltage regulator located in the switchgear.**

Frequency regulation must be isochronous from no load to rated load. The voltage regulator must be solid-state design and must provide no load to full load regulation within plus or minus one percent of rated voltage during steady-state conditions.

Performance criteria must be equal to the specified equipment. A rheostat must provide a minimum range of plus or minus 10 percent voltage adjustment from rated value.

The alternator, exciter, and voltage regulator must be designed and manufactured by the generator set manufacturer so that the characteristics are matched to the torque curve of the prime mover. The system must provide automatic voltage reduction if the load demand exceeds the engine capacity to prevent engine stalling and saturation of magnetic components. Systems that routinely select a linear-type (or straight line) constant volts/hertz characteristic without regard for the engine power and torque characteristics are unacceptable.

Upon one-step application of any load up to 100 percent of the rated load at 0.8 power factor, the voltage dip must not exceed 20 percent and must recover to plus or minus 2 percent of rated voltage within one second.

Furnish a resettable line current sensing circuit breaker with inverse time versus current response. This breaker must not trip within the 10 sec. specified above to allow selective tripping of downstream fuses or circuit breakers under a fault condition. This breaker must not automatically reset preventing restoration of voltage if maintenance is being performed. Generator breaker must selectively coordinate with downstream overcurrent protection devices. Breaker must be provided with adjustable long time, short time, and instantaneous settings as required to achieve coordination.

The generator, with a single maintenance-free bearing, must be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

4.17.3.3. **Control System. Provide a generator mounted solid-state microprocessor control and starting panel for the standby power generator system, incorporating complete controls for the functions of the generator set and associated mechanisms. The panel must be of the dead front type, NEMA 1 construction and must be mounted and wired to the generator set by the engine generator set manufacturer. Control wiring must have termination identification on each wire.**

Engine-generator controls must include the following:

- Two-wire, 24-volt DC engine controls including oil pressure gauge, coolant temperature gauge, and charge rate ammeter.
- A manual selector switch providing three control positions, RUN-STOP- REMOTE, must be included on the console. The RUN position must permit the engine to be started locally at the sot and run unloaded; the STOP position must serve as the RESET for alarm shutdown conditions; and the REMOTE position must allow automatic starting on a signal from the pump control panel.
- Control console containing complete controls, which start the engine on closing contact, and stop the engine on opening contact. The starting controls must be operated either manually or from a contact provided on the automatic transfer switch. When the engine fires, the starting controls must be disconnected automatically. If the engine fails to fire or any safety device should operate while the engine is running, the engine must stop immediately, and the starting controls locked out until manually reset.

- Generator controller must provide overload and short circuit protection required for the generator.
- Solid-state voltage regulator.
- Manual reset field circuit breaker.
- Control Panel mounted Emergency E-Stop: Flush; wall mounted, unless otherwise indicated; and labeled. Push button must be protected from accidental operation.
- AC output controls including voltmeter, ammeter, frequency meter, running time meter, voltage adjusting rheostat, and speed potentiometer.

The required inputs and outputs to and from the generator, automatic transfer switch and pump control panel for control, monitoring and alarm are shown on the drawings. These must include, as a minimum,

- Utility service failure alarm
- Generator start control
- Generator running status
- Generator failure alarm
- Station on generator power status
- Generator not in auto status
- Low oil alarm
- High temperature alarm
- Low gas pressure alarm

Alarm signals to the Pump Control Panel must be wired to terminal blocks inside the generator enclosure for customer connection.

4.17.3.4. **Outdoor Weather-Protective Sound Attenuating Enclosure. Provided a sound-attenuating enclosure for the generator which must allow the generator set to operate at full rated load in the ambient conditions. The enclosure must reduce the sound level of the generator set while operating at full rated load to a maximum of 75dBA at any location 23 ft. from the generator set in a free field environment. Housing configuration and materials used may be of any suitable design which meets application needs, except that acoustical materials used must be oil and water resistant. No foam materials must be used unless they can be demonstrated to have the same durability and life as fiberglass.**

The enclosure must include hinged doors for access to both sides of the engine and alternator, and the control equipment. Key-locking and pad-lockable door and latches must be provided for the doors. Door hinges must be stainless steel.

Provide an enclosure with an exhaust silencer which is mounted inside of the enclosure, and allows the generator set package to meet specified sound level requirements. Silencer and exhaust must include a rain cap and rain shield.

Prime sheet metal for corrosion protection and finish paint with the manufacturer's standard color. Prime and paint surfaces of metal parts.

Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts will not be acceptable. Use fasteners that are corrosion resistant and designed to minimize marring of the painted surface when removed for normal installation or service work.

Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110% of rated load for 2 hr. with ambient temperature at top of range specified in system service conditions.

Louvers: Fixed-engine, cooling-air inlet, and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

Automatic Dampers: At engine cooling-air inlet and discharge. Dampers must be closed to reduce enclosure heat loss in cold weather when unit is not operating.

Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

4.17.4. **Execution**.

4.17.4.1. **Installation. Mount the generator and securely anchor to the concrete pad. Install the standby power generator system as indicated on the plans and in conformance with the Manufacturer's recommendations.**

Install a generator concrete pad must be as shown on the drawings with a minimum 6-in. clearance around. Where access platforms and stairs are necessary, provide properly sized concrete pad as well as turn downs for the platforms and stairs.

4.17.4.2. **Field Quality Control. Verify that fuel piping, electrical connection, and exhaust piping work is complete. Demonstrate operation with selector switch in hand-off-automatic positions. Demonstrate performance of engine water jacket heater by filling the engine cooling system with coolant at room temperature. Energize the water jacket heater, determine the load current to the heaters and verify that water is rising in temperature using hand sensation as a detector.**

Automatic Transfer Switch. Verify that the transfer switch transfers to engine-generator source when normal supply voltage is less than 90 percent of rated voltage and retransfers when normal supply is 100 percent of rated voltage. Use suitable test instruments to verify voltages. Verify that failure of engine generator power source causes transfer to normal power supply by operating generator load circuit breaker. Check sensor operation to prevent transfer to emergency power until the generator output reaches 100 percent of voltage and frequency. Use suitable test instruments to verify voltages.

Control Panel: Electrically check automatic engine shutdown controls as the engine proceeds through its start-up sequence as follows:

- Engine Over-crank – Disconnect one wire from the fuel supply solenoid valve and turn the manual selector switch to the run position causing the engine to attempt to start for the period and number of cycles defined for over-crank alarm contacts to close. Verify over-crank alarm actuation and lockout. Reconnect the wire to the fuel supply solenoid valve and start the engine by turning the manual selector switch to the run position.
- Low Oil Pressure – Electrically short out the low oil pressure switch contacts to verify engine shutdown.
- High Coolant Water Temperature – Electrically short out the high coolant water temperature thermostat contacts to verify engine shutdown.
- High Lubrication Oil Temperature – Electrically short out the high coolant water temperature thermostat contacts to verify engine shutdown.
- Engine Overspeed – Manually adjust speed into overspeed range to verify engine shutdown.

Generator Remote Alarms: Provide the following alarm signals to the Pump Control Panel:

- Generator Over-crank
- Generator Running
- Generator Fail
- Generator Not In Auto
- Loss of Gas Pressure
- Low Oil
- High Oil Temperature

Engine Generator Operation:

- With normal electrical power supply to transfer switch, open main circuit breaker to verify that initiating contractor closes to start automatic sequence. Engine should start and control panel instruments should show voltage and frequency reach approximately rated value.
- Close normal power main circuit breaker. Verify that the automatic transfer switch transfers load back to normal power, initiating contactor opens, beginning the automatic stop sequence. Verify that the generator set stops automatically if the engine has a failure.
- Start and stop engine generator at least six times within a 2-hr. time period to verify operation.
- Demonstrate that safety devices furnished for automatic engine shutdown will cause engine shutdown when actuated.

Conduct a 4-hr. load bank test on the generator and submit a field report indicating the test results.

Coordinate, connect and test require inputs and outputs between the generator system, automatic transfer switch and pump control system.

An authorized representative of the manufacturer must attend startup activities to assist the Contractor with installation, testing and certifying the system.

4.18. **Motor Control Center**. Furnish and install a complete motor control center including required number of vertical sections, main breaker, digital meter, surge protective device, combination type motor starters, circuit breakers, magnetic relays, selector switches, push buttons, pilot lights, control transformers and special controls as shown on the plans and specified herein. An automatic transfer switch, panelboard, and transformer must also be included in the MCC.

The motor control center must be new and limited to products regularly produced and recommended for service ratings in conformance with engineering data or other comprehensive literature. In cases where device, or devices, or part of equipment is herein referred to in singular, reference must apply to as many items as required to complete installation.

4.18.1. **Special Requirements**. The Motor Control Center must be furnished, programmed, commissioned, and tested by the Pump Control System Supplier. The electrical contractor must install the Motor Control Center and provide conduit and wiring.

The plans indicate certain motor starters to be energized by a programmable controller output. If the current rating of the output is not enough to energize the starter directly, provide an interposing relay in the motor starter compartment and wire the relay as required to energize the starter.

Install Motor Control Center on concrete base. Coordinate size and location of concrete base.

The dimensions on the plans for the Motor Control Center are the maximum allowable dimensions for the Motor Control Center. Provided dimensions allow for installation of the basis of design electrical components as detailed below and elsewhere on the plans and specifications. Be responsible for any changes in the work made necessary from the installation of equipment other than the basis of design. Changes must be done without any additional cost to the Department or delay to project completion.

4.18.2. **Regulations and Standards**. Comply with the Regulations, Standards, and Publications listed below:

- UL Underwriters' Laboratories, Inc.
- NEC
- NEMA
- ANSI

4.18.3. **Submittals**. Shop drawings must be complete and must indicate dimensions, installation methods, size, weight, capacity, ratings, integral controls and types of materials, elevations, and sections. Shop drawings must include manufacturer's literature and complete information on the following:

- Freestanding Vertical Sections
- Main Circuit Breakers
- Digital Meters
- Surge Protective Devices
- Automatic Transfer Switch
- Thermal-magnetic Type Circuit Breakers
- Magnetic Across-the-Line Motor Starters
- Control Transformers
- Relays
- Selector Switches
- Push Buttons
- Pilot Lights
- Elapsed Time Meters
- Special Controls
- Engineered Control Diagrams and Connection Diagrams
- Nameplate Schedule
- Variable Frequency Drives and Solid State Starters

4.18.4. **Products**.

4.18.4.1. **Manufacturer. The Motor Control Center basis of design is Square D Model 6. Equivalent equipment as manufactured by Eaton Corporation is acceptable subject to approval and compliance with specific requirements listed herein. Contractor is responsible for any additional work required due to the selection of equipment other than the basis of design at no extra cost to the Department.**

4.18.4.2. **Motor Control Center Structure and Configuration. Provide a Motor Control Center that is NEMA Type I, gasketed. Wiring must be NEMA Class II, Type C. The motor control center must have a main breaker as indicated on the plans to feed the horizontal bus. Provide lugs of adequate size to terminate incoming cables. Furnish a motor control center with a ground bus.**

Motor starter units must be combination type with a molded case circuit breaker. Control voltage for units must be 120 volts. The Motor Control Center must be rated 480V, 3 phase, 3 wire, 60Hz and must be braced to withstand a short circuit current of 65,000 rms symmetrical amps. The motor control center must consist of vertical sections bolted together to form a rigid, freestanding assembly.

Form vertical sections of 13 gauge hot rolled steel with uniform blemish-free surfaces. Top and bottom structural parts must be 10 gauge. End closing plates must be 12 gauge, and unit parts and doors must be 14 gauge. Provide base channels constructed of rugged steel to easily withstand the stress of transit and moving the control center into position. Provide bolt holes in the base channels in the sections for the purpose of bolting the control center to the floor. Provide steel removable lifting angles on the top of the sections for convenience in handling the control center.

Each section, to comply with standards of NEMA, must be approximately 90-in. high excluding lifting angles and base channels. It must be approximately 20" deep and width must be as required for the application or as indicated on the Drawings.

End sections must have end-closing plates, which can be removed for the addition of future sections. The top plate must be of a removable one-piece construction for added convenience in cutting conduit holes. Removable blank plates flanged on 4 sides and with captive screws must cover unused unit spaces.

4.18.4.3. **Main Circuit Breaker. Where shown, main circuit breakers must be provided, individually mounted, and identified. The main breakers must have enough interrupting capacity to properly close against and interrupt instantaneously, without damage, the maximum short circuit current available to the breaker. Minimum interrupting capacity must be 65,000 amperes symmetrical at 480V. The main breaker must be 100 percent rated. Furnish main circuit breakers with GFI protection. Provide auxiliary contacts for the main circuit breakers and the automatic transfer switch to remotely signal breaker position and switch status to the pump control system PLC.**

4.18.4.4. **Digital Meter. Provide a digital meter in the Motor Control Center to provide complete electrical metering for the active service. The digital meter must be microprocessor based and must be furnished complete with current transformers. The digital meter must be Square D PM5000, Eaton, or approved equal. Furnish a digital meter with an alarm contact for remote indication of a power failure on any of the three phases. Provide optional communication interface and power management software and connect via network communications to Pump Control System.**

In addition to the digital meter, install a three-phase monitor to sense the presence of utility power on the line side of the utility main circuit breaker. The monitor must output a discrete signal which must be hardwired to the PLCs in the Pump Control Panel for monitoring. The three-phase monitor must be ATC Diversified Electronics SLA (230/440) ALE, Eaton, or approved equal, with voltage rating as required.

4.18.4.5. **Internal Surge Protection. Where shown as internally mounted, furnish a surge suppressor in the Motor Control Center for each normal and emergency service feeder. The surge suppressor must be UL 1449. Provide a disconnecting means must be provided ahead of the surge suppressor so the unit can be serviced without de-energizing the service.**

Unit must be furnished with dry contact alarm outputs to indicate any module failure. Surge suppressor must have AC tracking filter with EMI/RFI filtering. Each module must be fused individually, thermally protected, and have LED indication.

Unit must be provided and installed by MCC manufacturer.

4.18.4.6. **Horizontal Wireways. Provide adequate conduit entrance space and wire entry room at both the top and bottom of each section. The bottom horizontal wireway must be 12 in. and the top horizontal wireway must be 6 in. and both must extend through the length and depth of the control center section with openings between sections. Equip covers over these wireways with captive type screws to prevent loss of hardware during installation. Isolate these wireways from the bus bars.**

4.18.4.7. **Vertical Wireways. Install a vertical wire trough located on the right-hand side of each standard section that has a cross-sectional area of not less than 28 sq.in. It must extend from the top horizontal wire trough to the bottom horizontal wire trough for the purpose of routing user's motor and control wires to the control units. Isolate the wire trough from the bus bars to guard against accidental contact. Cover the vertical wire trough with a separately hinged door with captive type screws for safe and easy access to wiring without disturbing control units. Furnish wire ties in the vertical wire trough to group and securely hold wires in place for a neat, orderly installation.**

Where wire access ports between unit spaces and vertical wire trough are open, provide shutters to prevent items, such as a fish tape, from accidentally entering the unit space. Snap-in wire grommets must be provided in wire access ports for size 2 units and smaller for isolation and added protection of small wires. For larger units) snap-in wire guards must be provided for added protection of larger wires.

4.18.4.8. **Vertical Sections. Divide each vertical section into compartments, each containing a combination starter, circuit breaker, or other control assembly as indicated on the plans. Provide power to these compartments from the main bus by bus bars extending the full height of the unit. Also provide sections with horizontal spaces at the top and at the bottom, which must line up with adjacent section to form horizontal wiring raceways along the entire length of the control center.**

4.18.4.9. **Compartments. Build compartments in interchangeable combinations of modular heights. A full vertical section must contain six equal NEMA Size I modular compartments exclusive of top and bottom wiring spaces. Starter compartments must not be less than 12 in. high. Only 1/2 and integral multiples of the basic module will be allowed. Compartments for NEMA Size 4 and smaller starters must be draw-out type.**

Provide guide rails in the structure for supporting and aligning a unit during its removal or replacement. Draw-out units must have pressure type, line disconnecting stabs of high strength alloy and must be held in place by means of quick acting, captive machine screw fasteners arranged so the units can be removed or remounted readily without access to the rear of the structure. Enclose and effectively baffle each compartment whether draw-out or stationary, to isolate any fault which may occur and must be covered by an individual door fixed to the structure with a continuous full length piano hinge or two (three for doors over 36-in. high) semi-concealed, heavy-duty, pin type hinges. Secure doors with captive, quick acting machine screw fasteners and arrange to completely cover live parts whether the draw-out unit is present or not.

Provide doors two space factors (24-in. high) and larger with stainless-steel handles and stainless-steel hardware, for ease of opening.

4.18.4.10. **Bus Bars. Provide main horizontal bus bars rated as indicated on the plans but not less than 1000 amperes placed at the top or center of the control center and extending its entire length, except when cut and supplied with splice bars to divide the control center for ease in handling or when section is indicated on the plans to be furnished without bus.**

Mount horizontal bus bars of copper edge-to-edge to provide greater mechanical strength. Vertical copper bus bars must be rated not less than 600 amperes for adequate current carrying capacity in a variety of plug-in applications. Horizontal and vertical bus bars must be electrolytically tin-plated copper. Join connections between horizontal and vertical busses by bolts, conical spring washers for constant pressure joints, and self-clinching nuts to allow joint maintenance from the front.

Use high strength glass reinforced alkyd insulators as bus supports and as unit plug-in insulators. Bus and plug-in insulators must be red to indicate the proximity of energized bus parts.

The temperature rise, above ambient temperature outside the enclosure, of bus bars and connections must not exceed 120°F and that of connections to insulated cable must not exceed 115°F when operated continuously at rated current. Buswork, wiring and equipment must be rated to withstand short circuits of 65000 rms symmetrical amperes at 480 volts or as noted on the plans.

Provide a copper ground lug in each incoming line vertical section capable of accepting a #8 to 250 MCM cable, A horizontal and vertical copper ground bus must be provided in each section of the motor control center. Horizontal ground bus must run continuously throughout the control center except where splits are necessary for ease of shipment and handling; in which case, splice bars must be provided. Ground bus must be tin plated copper and have a cross-sectional area of equal to 28% of the main horizontal bus cross-sectional area. Horizontal ground bus must be located at the bottom of the motor control center.

Where required, a full rated tin-plated copper neutral bus must be provided.

4.18.4.11. **Bus Barrier. Furnish insulated horizontal and vertical bus barriers to reduce the hazard of accidental contact, these barriers must have a red color to indicate proximity to energized busses. Supply vertical bus barriers with interlocking front and back pieces to give added protection on every sides**

and must segregate the phases from each other. Small, separate openings in the vertical bus barriers must permit unit plug-in contacts to pass through and engage the vertical bus bars.

Provide bottom bus covers below the vertical bus to protect the ends of this bus from contact with fish tapes or other items entering the bottom of the enclosure. Unused plug-in openings must have plastic snap-in closing plates.

4.18.4.12. **Unit Plug-in. Unit plug-in contacts must be provided for size 1 through size 5 motor starters and for branch circuit breakers.**

The plug-in connection must be 2-point connection for each phase designed to tighten during heavy current surge. The plug-in fingers must be tin plated to yield a low resistance connection and must be backed by spring steel clips to provide high-pressure connection points. Mount contact fingers in their support so these fingers become floating and self-aligning to allow solid seating onto the vertical bus bars.

4.18.4.13. **Unit Doors. Each unit must have a door securely mounted with hinges, which allows the door to swing open a minimum of 112 degrees. Fasten unit doors to the stationary structure, so they can be closed to cover the unit space when the units have been temporarily removed. Unit doors must be held closed with captive type screws, which engage self-aligning cage nuts. These screws must provide at least 2 threads of engagement to help hold unit doors closed under fault conditions. Removable door panels held captive type screws must be provided on starter unit doors for mounting push buttons, selector switches or pilot lights. Furnish blank door panels capable of accepting future push button devices when push button devices are not originally specified for starter units. Starter units must have an external low-profile overload reset button.**

Flush mount pilot devices and instruments, including push buttons, reset buttons, and indicating lights, in the compartment doors. Do not mount equipment on the rear of draw out units. Arrange equipment within the unit to provide ample electrical clearances and easy access for maintenance. Draw out combination starter unit of a given type and size must be made interchangeable. Only mount those items, which are common to the starters, in the unit.

4.18.4.14. **Unit Support Pan. Support and guide each plug-in unit by a tilt and lift-out removable pan, so unit rearrangement is easily accomplished. For easy unit installation and rearrangement, transfer this unit support pan from one location to another without the use of tools after the unit and door have been removed.**

4.18.4.15. **Unit Saddles. Each plug-in unit must have a sheet steel saddle designed to physically isolate the unit from the bus compartment and adjacent units. Equip saddles with captive, self-aligning mounting screws, which hold the unit securely in place during shipment and maintain the unit and structure at the same potential. Provide handholds on each plug-in unit to facilitate unit removal.**

4.18.4.16. **Disconnect Operator. Supply a flange mounted operator handle for each switch or breaker. To prevent false circuit indication, this mechanism must be engaged with the switch or breaker at all times regardless of unit door position. The operator handle must have a conventional up-down motion with the down position as 'OFF." It must be possible to lock this handle in the "OFF" position with up to three 3/8 in. diameter shackle padlocks. The operator handle must be color coded to display red in the "ON" position and black in the "OFF" position.**

The operator handle must be interlocked with the unit door so the disconnect cannot be switched to the "ON' position unless the unit door is closed. It must be possible to defeat this interlock by a deliberate act of an electrician should he desire to observe the operation of the operator handle assembly. This interlock must also prevent opening the unit door unless the disconnect is in the "OFF" position. A defeater for this action must also be provided in the event an electrician must gain access to the unit without interrupting the service.

4.18.4.17. **Starter Units. Starter units must be completely draw out Type B, sizes as indicated on the plans, so units may be withdrawn without disconnecting any wiring. Units over three space units high may be**

bolt-in type. Provide a positive guidance system to assure proper alignment of wedge-shaped power stabs in dead-front openings in vertical power bus. The screw racking mechanism must serve as a mechanical advantage to the operator during unit insertion or removal. Stab-in power terminals must be of a type that will increase contact pressure on short circuits.

Starter units must be rated to withstand short circuits of 65,000 rms symmetrical amperes at 480 volts or as noted on the plans.

Furnish starter units with start counters.

Provide individual 3-Phase monitors that instantly turns off the starter upon phase interruption or loss. Electrical overloads will not be accepted for this function.

4.18.4.18. **Thermal Magnetic Circuit Breakers. Supply thermal magnetic circuit breakers with quick-make, quick-break mechanisms and must visually indicate whether the breaker is closed, open or tripped.**

Breakers must have enough interrupting capacity to properly close against and interrupt instantaneously, without damage, the maximum short circuit current available at the breaker. Minimum interrupting capacity of breakers must be 65,000 amps rms symmetrical at 480 volts. Provide auxiliary contacts on the circuit breakers where indicated on the plans.

Provide adjustable Long Time, Short Time, and Instantaneous trip settings for breakers 250 Amps and larger.

4.18.4.19. **AC Magnetic Starters – Line Voltage Type. Motor starters must be across-the-line magnetic type, rated in conformance with NEMA standards, sizes, and horsepower ratings. Supply starter in sizes as indicated on the plans. Minimum starter size must be NEMA 1.**

Supply across-the-line magnetic starters equipped with double-break, silver alloy contacts. Contacts must be replaceable without removing power wiring or removing starter from panel.

Coils must be of molded construction and must operate on 120 volts AC. Coils must be replaceable from the front without removing the starter from the panel.

Overload relays must be electronic. Provide Allen Bradley Bulletin 193 E1, Model EE Square D, or approved equal.

Provide motor starters with three phase monitors which must disconnect the corresponding load during single phasing conditions.

Provide individual 3-Phase monitors that instantly turns off the starter upon phase interruption or loss. Electrical overloads will not be accepted for this function.

4.18.4.20. **Electrical Interlocks. Furnish starters with electrical interlocks as shown on the plans plus 2 spare normally open and 2 spare normally closed contacts. Arrangements must be convertible from normally open to normally closed.**

4.18.4.21. **Control Transformers. Provide a control transformer for each motor starter control circuit as indicated on the plans. Control transformers for individual control circuits must be 480 volts to 120 volts and must be protected according to code. Size must be as required plus 50VA spare capacity. Primary fuses must be Class "CC."**

4.18.4.22. **AC Magnetic Relays. Provide 600-volt ac magnetic relays with convertible contacts and rated for 0 to 600 volts, inductive, 60 ampere make, 6 ampere break, 10 ampere continuous, with a minimum of 4 poles and provisions to add up to 4 poles making a total of 8.**

Contacts must be double-break, silver. Contacts must be convertible from normally open to normally closed or vice versa, without removing the relay from the panel or enclosure. Contacts must be color coded or engraved with respective normally open or closed symbol to indicate status.

Coils must be molded construction, continuous duty rated, and must operate on 120 volts AC.

Provide terminals with pressure wire connectors.

4.18.4.23. **Switches. Selector switches must be non-illuminated. Switches must be 30.5 mm, heavy-duty, oil tight. Switches must have double-break silver contacts. Switches must be maintained contact type unless otherwise indicated on plans. Provide auxiliary contact blocks as indicated on the plans or in the Description of Operation.**

Emergency stop pushbuttons must be snap type maintained contact, push to open, pull to close, mushroom style switches. Allen Bradley 800 series, Square D, or approved equal.

4.18.4.24. **Push Buttons. Push buttons must be non-illuminated. They must be 30.5 mm, heavy-duty, oil tight. Contacts should be rated for 10 amps minimum. Push buttons must be normally open or normally closed, as required, momentary contact type, unless otherwise noted on the plans.**

4.18.4.25. **Pilot Lights. Provide LED pilot lights with push to test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12 – 130V DC/AC power and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Generally, color caps must be green for "run" and red for "stop" or "off".**

4.18.4.26. **Elapsed Time Meters and Timers. Supply elapsed time meters that are time totalizer, non-resettable. They must have a synchronous motor, which must drive a set of digit readout wheels to indicate the total time the unit is energized. Readout must be five-digit including 1/10 digit. Range must be 0 to 9999.9 hr. Voltage rating must be 120 volts. Elapsed time meters must be ENM Company Series T50, Square D, or approved equal. Time meters must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the bucket.**

Repeat cycle timers must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the bucket. Timer must be Allen Bradley Model 700-HXM66SZ24, Square D, or approved equal.

4.18.4.27. **Identification. Fasten a control center identification number nameplate describing section catalog numbers and characteristics on the vertical wire trough door of every section. Each control center unit must have its own identification number nameplate giving unit catalog number fastened to the unit saddle near the upper left-hand corner. These nameplates must also have suitable references to factory records for efficient communication with supplier. Each control center unit must also have an engraved Bakelite nameplate fastened to the outside of each unit door.**

4.18.4.28. **Wiring. Wire the motor control center in conformance with NEMA class and type previously specified and must be furnished to be interconnected with a programmable controller system.**

Bore 120 VAC control wiring. Wiring for 24 vdc PLC inputs must be blue. Label wiring in each MCC cubicle.

Mount quick separating, pull apart terminals on lift-out brackets in the units. Label terminals.

4.18.4.29. **Finish. Painted parts must undergo a phosphatizing prepainting treatment for rust resistance and good paint bond. Use enamel paint, which must be baked for a durable, hard finish. Paint unit saddles white for easy interior visibility. Paint removeable push button plates, flange mounted operator handles and trim plates, and top horizontal wire trough cover plates a contrasting charcoal gray. Other painted parts must be painted ANSI-49 dark gray.**

Plate unpainted parts for resistance to corrosion.

4.18.5. **Execution**.

4.18.5.1. **Field Services. Perform startup and testing on the Motor Control Center.**

- Test the operation of each motor starter and MCC controls
- Program the automatic transfer switch and test the operation of the transfer with standby generator.
- The Engineer must have the option to witness start-up and testing.
- Conduits entering the bottom of the MCC must be extended a minimum of 2 in. above surface of equipment pad.

Training: Training must include theory of operation, maintenance and troubleshooting procedures, and programming methods. Conduct start-up, testing activities, and training activities on different days.

4.18.5.2. **Installation. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.**

Install motor-control centers on concrete bases. Coordinate size and location of concrete bases.

4.19. **Variable Frequency Controllers**.

4.19.1. **References**.

The Variable Frequency Controller (Drive) must be designed to meet the following specifications:

- NEC
- NEMA ICS 3.1 – Safety standards for construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems.
- NEMA 250 – Enclosures for Electrical Equipment
- UL 508A

4.19.2. **Qualifications**.

Manufacturer: Only manufacturers with a minimum of 10 yr. experience specializing in the design and manufacturing of PWM Drives will be acceptable.

Support: Only manufacturers who have maintained factory trained and authorized service facilities within 100 miles of the project and have a demonstrated record of service for at least the previous 3 yr. will be acceptable manufacturers. Full-time support personnel must be employed by the manufacturer.

Certification: Only manufacturers certified to ISO-9001 Series of Quality Standards with drive products manufactured in an ISO certified facility to assure quality and corrective action procedures have been adhered to must be acceptable manufacturers.

4.19.3. **Products**.

4.19.3.1. **Manufacturers. Variable Frequency Controller basis of design must be Square D with 3% line reactor or approved equal by Rockwell Automation or Benshaw. The Contractor must be responsible for changes in the work made necessary from the installation of equipment other than the basis of design. Changes must be done without any additional cost to the Department or delay to project completion.**

Mount the Variable Frequency Controller with solid-state by-pass starter in the MCC as shown on the plans and must meet the full load ampere requirements of the pump motors provided.

The Drive must have manual bypass capability using a solid-state reduced voltage starter where shown. The solid-state reduced voltage starter must be by Square D, or approved equal by Rockwell Automation or Benshaw

All engineering modifications required to meet the specifications and drawings must be provided by the manufacturer only. Modifications performed by third parties must not be accepted.

4.19.3.2. **Description. Only drives suitable for operating the indicated loads must constitute an acceptable product offering. The Drive must conform to requirements of NEMA Specification ICS 3.1. The Drive must fit in the space shown on the drawings.**

4.19.3.3. **Ratings.**

- The drive must accept an input voltage plus or minus 10%.
- For drives greater than 5 HP, the displacement power factor must range from 1.0 and .95 lagging, over the entire speed range.
- Efficiency should be a minimum of 97% at full load speed.
- Environmental ratings:
  - Storage ambient temperature range: -40 C to 70 C (-40 to 158 F)
  - Operating ambient temperature range: 0 C to 40 C (0 to 109 F) without derating.
  - The relative humidity range is 5% to 95% non-condensing.
  - Operating elevation: up to 3,300ft without derating.
- Output Power Ratings
  - The output voltage must be adjustable from 0 to rated motor voltage.
  - The output frequency range must adjustable from 0 to 320Hz.
  - The inverter section must produce a pulse width modulated (PWM) waveform using latest generation IGBTs.
- Sizing
  - Loads must be as required to serve the equipment provided.
  - Normal duty must provide 110 percent overload capability for up to 1 minute and 150 percent overload capability for up to 3 seconds.

- Heavy duty must provide 150 percent overload capability for up to 1 minute and 200 percent overload capability for up to 3 seconds.
- Normal duty must be provided unless otherwise indicated.

■ Definitions
- The Drive Unit must refer to the actual drive that will be mounted within the specified enclosure.
- The Drive System must refer to the drive unit and items specified under Drive System Options.

4.19.3.4. **Drive Unit Design.**

■ Hardware
- Use diode or fully gated bridge on the input.
- Use line reactor on all ratings.
- Use switching logic power supply operating from the DC bus.
- Incorporate phase to phase and phase to ground MOV protection.
- Use gold plated plug-in connections on printed circuit boards.
- Microprocessor based inverter logic must be isolated from power circuits.
- Use latest generation IGBT inverter section.
- Inverter section must not require commutation capacitors.
- Employ interface common for all horsepower ratings. Interface must include a LCD digital display, programming keypad and operator key options.
- Main Control Board must be common for all ratings.
- Control connection must be common for all ratings.
- Common Node Capacitors available on all frames.

■ Control Logic
- Ability to operate a drive with motor disconnected.
- Provide a controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit. Provide annunciation of the fault condition.
- Use an adjustable PWM carrier frequency within a range of 1-6kHz.
- Provide either Selectable Sensorless Vector or V/Hz modes.
- The drive must be suitable for use on either normal duty or heavy duty loads. If specified for normal duty, the drive must provide 110 percent overload capability for up to one minute and 150 percent overload capability for up to three seconds. If specified for heavy duty, the drive must provide 150 percent overload capability for up to one minute and 200 percent overload capability for up to three seconds.
- Provide multiple programmable stop modes including — Ramp, Coast, DC-Brake, Ramp-to-Hold and S-Curve.
- Provide multiple acceleration and deceleration rates.
- Make adjustments with the door closed.
- The drive must have an adjustable output frequency up to 60Hz.

■ Power Conditioning
- The drive must be designed to operate on an AC line which may contain line notching and up to 10% harmonic distortion.
- An input isolation transformer must not be required for protection from normal line transients. If line conditions dictate the use of a transformer, the K factor must be 4.0 or less.

4.19.3.5. **Drive Unit Features.**

■ Control Module
- Selectable sensorless vector or V/Hz mode selectable through programming.
- The sensorless vector mode must use motor nameplate data plus motor operating data such as IR drop, nominal flux current and flux up time.

- The volts per hertz mode must be programmable for preprogrammed fan curve, straight line, or full custom patterns.

- Current Limit
  - Programmable current limit from 0.1 amps to 150% of drive rated amps.
  - Current limit must be active for drive states: accelerating, constant speed and decelerating.
  - The drive must employ PI regulation with an adjustable gain for smooth transition in and out of current limit.
- Acceleration/Deceleration
  - Accel/Decel settings must provide separate adjustments to allow either setting to be adjusted from 0 seconds to 3600 seconds.
  - A second set of remotely selectable Accel/Decel settings must be accessible through digital inputs.
- Speed Regulation Modes
  - Open Loop
  - Slip Compensation with speed regulation from 0.1 to 0.5 percent.
  - Process PI control
- Speed Profiles
  - Programming capability must allow the user to produce speed profiles with linear acceleration/deceleration or “S-Curve” profiles that provide changing accel/decel rates.
  - S-Curve profiles must be adjustable.
- Adjustments
  - A digital interface must be used for set-up, operation, and adjustment settings.
  - All adjustments must be stored in nonvolatile memory (EEPROM).
  - No potentiometer adjustments must be required.
  - The drive must provide EEPROM memory for factory default values.
- Process PI Control
  - The drive must incorporate an internal process PI regulator with proportional and integral gain adjustments as well as error inversion and output clamping functions.
  - The feedback must be configurable for normal or square root functions. If the feedback indicates that the process is moving away from the setpoint, the regulator must adjust the drive output until the feedback equals the reference.
  - Process control must be capable of being enabled or disabled with a hardwire input. Transitioning in and out of process control must be capable of being tuned for faster response by preloading the integrator.
  - Protection must be provided for a loss of feedback or reference signal.
- Fault Reset/Run
  - The drive must provide up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart.
  - The automatic mode must not applicable to a ground fault, shorted output faults and other internal microprocessor faults.
  - The time between restarts must be adjustable from 0.5 seconds to 30 seconds.
- Skip Frequencies
  - Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance must be provided.
  - The set points must have a bandwidth adjustable from 0Hz to 60Hz.
- Run on Power Up: A user programmable restart function must be provided to automatically restart the equipment after restoration of power after an outage.
- Inertial Ride Through:
  - The drive must respond to a loss of AC input power by adjusting the output frequency to create a regenerative situation in the motor.

- The regenerated energy must recapture the mechanical energy and convert it to electrical energy that must power the drive logic during the power outage.
- The drive must retain control of the motor during the power outage.
- The performance must be based upon the amount of system inertia and the length of the outage.
- The amount of voltage drop required to trigger inertia ride through and the level at which regulation occurs must be adjustable.
- Inertial Ride Through must be capable of being enabled or disabled vial programming.

■ Fault Memory
- The last 8 fault codes with respective time must be stored in a fault buffer.
- Information about the drives condition at the time of the last fault such as operating frequency, output current, dc bus voltage and twenty-eight other status conditions must be stored.
- A power up marker must be provided at each power up time to aid in analyzing fault data.
- The last eight alarm codes must be stored, without time stamp, for additional troubleshooting reference.

■ Overload Protection
- The drive must provide internal Class 10 or 20 motor overload protection investigated by UL to comply with N.E.C. Article 430.
- Overload protection must be speed sensitive and adjustable.
- A viewable parameter must store the overload usage.

■ Auto Economizer
- An auto economizer feature must be available to automatically reduce the output voltage when the drive is operating in an idle mode (drive output current less than programmed motor FLA). The voltage must be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage.
- When the load increases, the drive must automatically return to normal operation.

■ Terminal Blocks: Separate terminal blocks must be provided for control and power wiring.

■ Flying Start: The drive must be capable of determining the speed and direction of a spinning motor and adjust its output to “pick-up” the motor at the rotating speed.

■ Ride Through: The control logic must be capable of “riding through” a power outage of up to 2 seconds in duration.

■ Inputs and Outputs:
- The standard Input/Output board must consist of both analog and digital I/O.
- No jumpers or switches must be required to configure inputs and outputs. Functions must be fully programmable.
- The Input/Output board must have the following analog inputs as standard: Minimum quantity of 2 differentially isolated plus or minus 10V (bi-polar) / 20mA, 9 bit plus sign, by common mode noise rejection. One input must be provided from the Primary PLC and one input must be provided from a Secondary PLC. A discrete input must be provided, as detailed below, to allow for selection of one of the above signals to be used for speed reference or control. Analog inputs must be user programmable for a variety of uses including frequency command and process loop input. Analog inputs must be user programmable for function scaling (including invert), offset, signal loss detect and square root
- The Input/Output board must have the following analog outputs as standard: Quantity 2 differentially isolated plus or minus 10V (bi-polar) / 20mA, 9 bit plus sign. One output must be provided to the Primary PLC and one output must be provided to the secondary PLC. The analog output must be user programmable to be proportional to one of fourteen process parameters including output frequency, output current, encoder feedback, output power. Programming must be available to select either absolute or signed values of these parameters.
- The Input/Output board must have the following digital inputs as standard: Quantity of 6 digital inputs rated 115Vac. Inputs must be individually programmable for functions from a list of 31 inputs

that includes Start, Run, Stop, External Fault, Speed Select, Jog and Process PI functions. One input must be provided and programmed to allow for selection of the speed reference or control signal from either the Primary PLC or the Secondary PLC as detailed above.

- The Input/Output board must have the following digital outputs as standard: Quantity of 2 relay outputs, form C (1 N.O. —1 N.C). Contact output ratings must be 250Vac / 30Vdc (2.0 Amps maximum), resistive or inductive. Relays must be programmable to 28 different conditions including Fault, Alarm, At Speed, Drive Ready and PI Excess Error. Timers must be available for each output to control the amount of time, after the occurring event, that the output relay actually changes state.
- Reference Signals: The drive must be capable of using the following input reference signals: Analog inputs, Preset Speeds, Remote Potentiometer, Digital MOP, Human Interface, Communication Module Commands.
- Loss of Reference: In the event of loss of reference signal, the drive must be user programmable to the following: Fault the drive, alarm and maintain last reference, alarm and go to preset speed, alarm and go to minimum speed, alarm and go to maximum speed, or alarm and maintain last output frequency.
- Metering: The following metering parameter must be accessible through the Human Interface: Output Current in Amps. Output Voltage in Volts, Output Power in kW, Elapsed MWh, DC Bus Voltage, Output Frequency, Last 8 faults, Elapsed Run Time.
- Faults: Fault information must be accessible through the Human Interface. At a minimum, the following faults must be displayed: Power Loss, Undervoltage, Overvoltage, Motor Overload, Heat Sink Over Temperature, Maximum Retries, Phase to Phase and Phase to Ground Faults.

4.19.3.6. **Drive System Options.**

- Enclosure
  - NEMA 1G with washable metal mesh filters on the outside of the enclosure door and over other vented openings
  - Paint: Manufacturer's standard.
  - Top entry and bottom exit for power cables.
  - Provide a 6.25" x 2" door mounted white lamacoid nameplate with black letters (message to be defined during submittal).
  - UL Label for UL panel recognition.
- Drive System Input Circuit Breaker. Provide a door interlocked circuit breaker disconnect.
- Drive input line reactor: Provide a drive input line reactor mounted within the drive system enclosure. The line reactor must meet the following: be iron core with an impedance of 5%, have copper windings, have Class H insulation with 115degree C rise, and be rated for system frequency and voltage.

4.19.3.7. **Manual Bypass with Reduced Voltage Starting. Provide means to manually switch a single motor from drive control to bypass (across the line) operation with soft start.**

Microcomputer must analyze the motor variables and generate control commands that control the motor to reduce the possibility of surges occurring in the system.

- The starting time must be adjustable from 2 to 30 seconds.
- The stopping time must be adjustable from 2 to 120 seconds.
- Provide separate contactors for drive output, RVSS output and total bypass. The total bypass contactor must be used to bypass the RVSS once the motor is up to speed and must be capable of starting and operating the motor if so wired in the field. The contactors must be electrically interlocked

Provide a door mounted VFD/Bypass selector switch and pilots lights for indication of VFD and Bypass modes of operation.

Provide a Class 10 overload for motor protection while operating in the bypass mode.

Provide a door mounted emergency stop pushbutton with red mushroom head and maintained contacts to deenergize the load in any operating mode.

Implement pump controls according to the schematics shown on the drawings; including incorporation of the necessary devices to monitor pump overtemperature, seal failure or RTD's, as required, in coordination with the System Supplier and Pump Manufacturer.

4.19.3.8. **Control Power Transformer. Provide a control power transformer mounted and wired inside of the drive system enclosure to supply enough control power for the VFD, the bypass controller and auxiliary instruments (pressure switches, etc.), as shown on the drawings.**

The transformer must be rated for drive, bypass, and auxiliary instrument power plus 250VA spare capacity for future customer use.

4.19.3.9. **Common Mode Choke. Provide a common mode choke at the drive output to help, in conjunction with the proper grounding techniques, reduce or eliminate interference with sensitive electronic equipment or communication devices installed in the same system.**

4.19.3.10. **Harmonic Mitigation Techniques.**

- None required, if the VFD is below 100HP.
- Provide VFD with Active Front End for drives 100HP and above.

4.19.3.11. **Auxiliary Relays. Provide relays for Drive Alarm, Drive Fault and Drive Run. Provide 2 additional relays to be wired per custom requirements.**

The relays must be Allen-Bradley 700HC24A1 relays (2 form C contacts, 2N.O. & 2N.C.), Square D, or approved equal. The relay contacts must be rated for 1I5VAC/30V DC, 5.0 Amp resistive, 5.0 Amp inductive.

- Control Interface
  - The control terminals must be rated for 115V AC.
  - Inputs must be optically isolated from the drive control logic.
- Hand-Off-Auto Selector Switch.
  - Provide a "Hand/Off/Auto" selector switch for start-stop control.
  - The devices must be Allen-Bradley Bulletin 800T pilot devices (30mm, NEMA Type 4/4X/13) mounted on the drive system enclosure door.
- Pilot Lights
  - Provide pilot lights, mounted on the enclosure door, for indication of Run, Stop and Drive Fault.
  - Pilot lights must be LED illumination type with push to test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12 – 130V DC/AC power, and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Generally, color caps must be red for "run" and green for "stop" or "off". Unused colored shrouds must be provided to the Engineer to allow for future customization and configuration of pilot light colors as desired or required by the Department.
  - Pilot Lights must be Allen-Bradley Bulletin 800T, Square D, or approved equal. Pilot lights will be NEMA Type or Type 4X as required, or approved equal.
- Motor Run Time Meter and Event Counter
  - Provide a digital, non-resettable, door-mounted elapsed time meter.

- The meter must be electrically interlocked with the Drive Run relay and Bypass contactor (if required) to indicate actual motor operating hours.
- Provide resettable door mounted event counter.

■ Human Interface Module
- Provide a door mounted Human Interface Module with integral display, operating keys, and programming keys.
- The Human Interface must be rated IP66 / UL Type 4X, 12.
- The display portion must have the following features:
  - The display must be a 7 line by 21 character backlit LCD display with graphics capability.
  - The display must show drive operating conditions, adjustments, and fault indications.
  - The display must be configured to display in three distinct sections. The first section must be a status display for direction, status, fault alarm conditions and Auto / Manual mode. The second section must display drive output frequency. The third section must be configurable as a display for either programming menus and information, or as a two-line user display for two additional values utilizing scaled units.
- The Human Interface must provide digital speed control.
- The keypad must include programming keys, drive operating keys (Start, Stop, Direction, Jog and Speed Control), and numeric keys for direct entry.

4.19.4. **Execution**.

4.19.4.1. **Quality Control.**

The vendor's manufacturing facility must be certified to the ISO-9001 series of standards from the International Standards Organization.

Inspect and test incoming material for conformance to the specifications. The manufacturer must employ a vendor certification program to assure the quality of incoming materials.

Inspect and test subassemblies for conformance to specifications.

Dynamically test control printed circuit boards for a minimum of 22 hr. while heat cycled 1 hr. at each temperature setting from 32°F to 140°F.

Subject drives to a Run-In Test with a properly sized motor and operated under cycling load conditions on a dynamometer. The Drive must be subjected to a Run-In Test that brings the Drive to full rated temperature.

Supplied drives must be Qualification Tested and must meet at least minimum testing for shorted output, capacitive coupling, chattering relay and showering arc.

The drives must carry an all-inclusive, 5-yr. parts and labor warranty from the manufacturer, and the warranty must include travel and other miscellaneous expenses.

4.19.4.2. **Start-up Commissioning Services. Start-up will be performed at the user's site. The service division of the VFD manufacturer must perform start-up services. VFD manufacture must provide a minimum of 2 days of on-site start-up service for each VFD. The use of third-party supplier start-up personnel is not acceptable.**

The installation contractor must coordinate with the supplier to provide the following.

■ A pre-installation meeting with the user to review the following: site ready condition checklist provided by the VFD manufacturer and completed by the installation contractor, the start-up plan, the start-up schedule, the drives installation requirements.

- Inspect the drives mechanical and electrical devices enclosed.
- Perform a tug test on internal connections within the drive and verify wiring.
- Verify critical mechanical connections for proper torque requirements.
- Verify and adjust mechanical interlocks for permanent location.
- Confirm sectional wiring is connected properly.
- Re-verify control wiring from any external control devices.
- Set up drive internal power supplies and thyristor control circuits.
- Verification of proper phasing from isolation transformer to drive.
- Confirm cabling of drive to motor, isolation transformer and line feed.
- Perform Megger test.
- Apply voltage to the drive and perform operational checks.
- Bump motor and tune drive to the system attributes. (If the load is unable to handle any movement in the reverse direction, the load should be uncoupled before bumping the motor for directional testing.)
- Run the drive motor system throughout the operational range to verify proper performance

4.19.4.3. **Standard Testing.The following tests must be carried out in conformance with applicable requirements and specifications of Canadian Standards Association (CSA), Underwriters Laboratories (UL), National Electrical Manufacturers Association (NEMA), European Standard (EN), and International Electrotechnical Commission (IEC).**

Perform functional checks wherever possible; otherwise, inspection and continuity checks must be made.

Component devices must be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.

Instruments, meters, protective devices, and associated controls must be functionally tested by applying the specified control signals, current, and voltages.

Drives must be inspected for the following:

- Control power failure test
- Rectifier gating checks
- Inverter gating checks
- Link converter tests
- Machine converter tests
- Load tests: Drives must be accelerated to the test motor's nominal frequency, under load, decelerated to 10 Hz, then accelerated back to test motors nominal frequency, with a ramp time of approximately ten seconds. This cycle must be repeated continuously for up to 1 hr. Drives must be tested under load at the test motor's nominal frequency.

4.19.4.4. **Physical Inspection. The product must meet applicable engineering and workmanship standards and specifications. Verify components against engineering documentation to be present and correctly installed.**

Warning plates, isolation barriers, and mechanical interlocks must provide enough safety or isolation for personnel and equipment.

- Warning labels and nameplates must be present and in their specified positions to advise personnel of possible hazards.
- Isolation barriers must be in place within the cabinet. Such barriers protect personnel from touching live components in an area that otherwise does not have power supplied to it.

- Verify operation of isolation switch handle and door interlocks. The interlocking prevents the opening of any medium voltage door on a medium voltage cabinet when the isolation switch handle has been moved to the full ON position.

Check bus and bus connections for proper clearance, creepage, phasing, and torque.

4.19.4.5. **Witness Testing. VFD supplier must make the VFD available for witness testing by the Department's representatives. Witness test must include a drive system run test that must consist of operating the variable frequency drive connected to a dynamometer. During the testing of the drive, provide a demonstration of the operator interface and functionally as well as demonstration of the operation of the drive. The drive will be tested up to rated horsepower at both steady state and varying speeds. VFD supplier must notify the Engineer 4 weeks in advance of testing date. At the conclusion of testing, the Engineer's representative will convene with the VFD manufacturers Application Engineer or Project Manager to discuss any concerns or issues that arose during the test. Any modifications or changes requested by the Department will be addressed at this meeting.**

A review of the electrical and mechanical drawings for the purchased equipment must be done with the Suppliers Application Engineer or Project Manager before commencing the tests. Any questions or clarifications, before commencing the test, will be addressed at this time.

Issue a Certified Test Report to the Purchaser at the conclusion of the testing.

4.19.4.6. **Warranty. VFDs and RVSSs must carry an all-inclusive 5-yr. parts and labor warranty from the manufacturer from the date of Substantial Completion. The warranty must cover all components. The warranty must include travel and other miscellaneous expenses.**

4.20. **Control Panels**. In so far as the requirements are applicable, provide control panels, control panel components, and control panel modifications performed under this Contract in accordance with this Specification. Unless otherwise indicated, control panels and control panel modifications must be provided by the System Integrator and must be complete and include components and wiring as shown on the plans and specified herein.

New control panels to be provided under this Contract include, but are not limited to, the following.

- Station Pump Control Panel (PCP) – See Specification for additional information.
- Manufacturer Packaged Pump Controller (PPCs) See Specification for additional information.
- Sludge Pump Control Panel (SPCP).
- Control components provided integral to the MCC.

Work to the Pump Control Panel include, but are not limited to:

- Development of programming for the PLC, associated OIT/HMI, and communication modems.
- Installation of PLC CPU unit.
- Provision of Ethernet Switch for integration of the Sludge Pump PPC and Strom Water PPC into the PLC.
- Provision of 24 VDC Power Supply, UPS unit, and associated Batteries.
- Provision and programming of communication modems and integration with the existing RTU.
- Integration of signals for the Pumps, ATS, VFDs, PPCs, Level Controller, and MCC into the PLC and Auxiliary Operation Control Loops.

Requirements of control components identified in this section apply to the entire project and are not limited to any particular control panel.

Furnish labor and materials required for providing remote access and I/O communication between the stations as shown on the plans and specifications. Data links are currently provided between the pump

station and the existing SCADA. The Contractor is responsible for the configuration of the modems and coordination with the telecom provider to ensure that modems are correctly configured and installed to provide transmission and reception of currently existing I/O and additionally specified I/O.

4.20.1. **Quality Assurance**.

Regulations and Standards:

UL	Underwriters' Laboratories
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
ANSI	American National Standards Institute
IEEE	Institute of Electrical and Electronic Engineers
ISA	Instrument Society of America

The control panel components must be of the most current and proven design. Specifications and plans call attention to certain features but do not purport to cover details entering the design of the control panels. The components provided by the System Supplier must be compatible with the functions required and must form a complete working system.

The control panels must be UL listed as a complete assembly in accordance with UL-508A.

Guarantee. Control panels must be guaranteed in writing for defects in materials and workmanship for a period of 2 yr. from the date of substantial completion. The warranty must be comprehensive, and must include parts, labor, travel, and other miscellaneous expenses.

4.20.2. **Submittals**. Submit shop drawings on the control panels in conformance with the requirements of the Instrumentation Section. Shop drawings must be complete in respects and must include a complete bill of material, catalog information, descriptive literature for components, UPS load studies, wiring diagrams, and panel layout drawings showing dimensions to devices.

4.20.3. **Products**.

4.20.3.1. **Control Components. Before being installed or implemented on field equipment, simulate the final modified program on the new PLC CPU. Perform complete closed loop checks for I/O to verify complete functionality of the new PLC CPU. Following installation and field testing, copy the final program onto the spare PLC CPU which will then be turned over to the Department.**

4.20.3.2. **Control Panel Enclosure. Design and size control panel enclosures in conformance with the requirements of the plans and as specified herein.**

Where required, additional freestanding enclosures must be NEMA 12, constructed of Type 316 stainless steel with continuously welded seams. Panel must have piano type hinged, overlapping doors with neoprene gasket. Enclosure doors must be equipped with a heavy-duty 3-point latching mechanism operated by a padlocking handle.

Where required, additional wall mounted enclosures must be NEMA 12, constructed of 14 gauge Type 316 stainless steel with continuously welded seams. Panel must have piano type hinged doors with neoprene gasket.

Properly identify control panel components with an engraved nameplate mounted on the inside of the panel. Components not mounted on the front of the panel must be mounted to a subpanel. Wiring must be installed in a neat workmanlike manner and must be grouped, bundled, supported, and routed horizontally and

vertically to provide a neat appearance. Wires leaving the panel must be terminated at the terminal strips inside the enclosure. Terminals and wires must be identified in conformance with the Supplier's panel wiring diagrams.

Provide a copper grounding plate inside the control panel for terminating ground wires.

Provide a plastic data pocket inside the control panel.

4.20.3.3. **Enclosure Light Fixture. Light fixtures must be low profile LED light strip design with the appropriate location and quantity of light fixtures to ensure adequate and full illumination of enclosed components but at least what is required to span across two-thirds width of the panel. Individual light fixtures must have an operating temperature of -22 to 140°F, provide 900 LM illumination, and have 5-watt power draw. The light fixture must be Hoffman Part Number LED24V15 with appropriate power supply for installation in unclassified environments or equivalent by Halo. Fixtures within classified environments must be Hoffman Product Series LEDHL24V or equivalent by Halo.**

4.20.3.4. **Enclosure Cooling Fan and Exhaust Grills. Provide a cooling package for the control panel. The cooling system must be sized to keep the panel temperature below the maximum operating temperature of the equipment housed. A thermostat located in the control panel must control the cooling system. The cooling system must be Hoffman, nVent, or approved equal.**

4.20.3.5. **Control Circuit Breakers. Circuit breakers must be quick-make, quick-break thermal magnetic molded case type individually mounted and identified. Circuit breakers must be Allen-Bradley Bulletin 1492-CB, Omega, or approved equal by Moeller.**

4.20.3.6. **120 VAC Uninterruptible Power Supply (UPS). Provide 120VAC Tower UPS units for the Pump Control Panel and Sludge Pump Control Panel.**

Furnish UPS units with an alarm contact to indicate when the UPS is operating on battery power and when the UPS has failed or requires maintenance. Alarms must be monitored by the PLC's.

UPS units must have built-in USB port and 6 built-in UPS supported outlets. UPS units must include the optional bypass (PDU) that enables replacing the UPS with a 'hot-swappable' replacement unit with no disruption to connected equipment.

Size the UPS to power 100% of the full panel load for 1 hr.

The UPS must be Tripp Lite Model BCPRO. No substitutions must be accepted.

4.20.3.7. **24 VDC Uninterruptible Power Supply (UPS) and Batteries. Provide 24 VDC UPS units as indicated for each group of equipment on the plans and as specified within the individual equipment specifications.**

Furnish din-rail mounted UPS with an alarm contact to indicate when the UPS is operating on battery power and when the UPS has failed or requires maintenance. Alarms must be monitored by the Pump Control Panel PLC's.

UPS batteries must be valve regulated, spill proof construction, allowing safe operation in any position. Batteries must have rugged impact resistant ABS case and cover (UL94-HB) and must be UL recognized.

UPS must be rated for 0 Amps to 15 Amps output current at 24 VDC. Batteries must be 12 VDC with 40 Amp-Hours of capacity.

The UPS must be rated for -32°F to 140°F and batteries must be rated for up to -32°F to 120°F.

The UPS must be SITOP 24 VDC UPS, Model 6EP1 931-2EC42 by Siemens with high temperature battery. Batteries must be PS-12400 by Power-Sonic Corporation.

4.20.3.8. **Unmanaged Ethernet Switch. Provide an unmanaged DIN rail mounted Ethernet switch for installation in the Pump Control Panel to expand the number of available RJ-45 Ethernet ports and allow for integration of the Motor Protection devices or systems, pump electronic modules, building systems, and power monitoring components provided as part of the Automatic Transfer Switch and the MCC into the PLC at the Pump Control Panel. Switches must have the characteristics as shown below:**

Table 1
Switch Characteristics

Input Power:	Redundant 10-30 VDC
Humidity:	10% to 95% (Non-Condensing)
Operating & Storage Temperature:	-40°C to 85°C
Mean Time Between Failure:	>2 million Hours
Ports:	16 - 10/100BaseTX RJ-45 Ports
Humidity:	10% to 95% (Non-Condensing)
Operating & Storage Temperature:	-40°C to 85°C

Switch must have IEEE 802.3 Compliance, ESD and Surge Protection on Built-in Ports, and have Autosensing 10/100BaseTX, Duplex, and MDIX. Switch must be provided with a serial configuration port and must have Bi-Color Status LEDs For Link, Speed, Activity & Duplex. Switch must be the N-TRON 316TX-N 16-Port Unmanaged Industrial Ethernet Switch by Redlion, Phoenix Contacts, or approved equal.

4.20.3.9. **Selector Switches. Supply selector switches that are 30.5mm heavy-duty non-illuminated. Switches must have double-break silver contacts. Switches must be maintained contact type unless otherwise indicated on the Drawings. Provide auxiliary contact blocks on switches where indicated on the plans or in the Description of Operation. Provide a gray legend plate for each switch with white marking as indicated on the plans. Selector switches must be Allen-Bradley Bulletin 800T NEMA Type 4, or equivalent by Phoenix Contacts, or approved equal.**

4.20.3.10. **Push Buttons. Push buttons must be 30.5mm, heavy-duty, non-illuminated. Push buttons must have double-break silver contacts. Push buttons must be momentary contact type) color-coded as indicated on the Drawings. Push buttons must have flush heads. Provide a gray legend plate for each push button with white marking as indicated on the Drawings. Push buttons must be Allen- Bradley Bulletin 800T, NEMA Type 4.**

4.20.3.11. **Pilot Lights. Supply LED pilot lights, heavy duty with push-to-test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12-130V DC/AC power and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Pilot lights must have a nominal diameter of 30 mm for installation in 30.5mm openings. Unused colored shrouds must be provided to the Department with each control panel to allow for future customization and configuration of pilot light colors as desired or required by the Department.**

Pilot Lights must be Allen-Bradley Bulletin 800T, NEMA Type 4/4X and 13 as required, or equivalent by Phoenix Contacts, or approved equal.

Pilot Lights for installation in NFPA defined hazardous locations and classified areas must be Allen-Bradley Bulletin 800H, Type 4, 7, & 9, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.12. **Relays. Relays must be heavy-duty general-purpose type with 10 amp contacts. Relays must have terminals, which plug-in to a socket, mounted to the inside of the panel enclosure. Terminals for**

relays with AC coils must be pin type, and terminals for relays with DC coils must be blade type with number of poles as required.

Relay coils must operate on 120 volts AC, unless indicated otherwise on the plans. Relays must have an indicator light to indicate the relay coil is energized. Relays must be Idec RR Series or equivalent by Phoenix Contacts.

Main input relays for field devices must be 4 pole with outputs assigned as shown on the drawings.

Relay inputs, including coil wiring, must be wired through terminal blocks. Outputs must be 24 volts to interposing relays. No direct wiring must be allowed to relays or PLC output cards.

4.20.3.13. **Intrinsically Safe Relays. Provide intrinsically safe relays as required by applicable electrical codes.**

The intrinsically safe relay must be a single channel repeater with a DPDT set of output contacts and must operate on 120 volts AC.

The intrinsically safe relays must be Stahl I.S., Isolators Type 9170, or equivalent by Phoenix Contacts.

4.20.3.14. **Intrinsically Safe Barriers. Provide an intrinsically safe barrier in the control panel as required by applicable electrical codes. The intrinsically safe barriers must be Stahl, or equivalent by Phoenix Contacts, or approved equal.**

4.20.3.15. **24 Volt DC Power Supplies. The new 24 VDC power supply for the Pump Control Panel must be DIN rail mounted and must be integrated with the new UPS and batteries specified above to provide battery backed up 24VDC to the components within the Pump Control Panel. Power Supply must be capable of receiving 85-132 / 176-264 VAC power (115/230 VAC, Auto Selecting) and providing 24 DC at 10 Amps (240W). Power supply must be rated for operation from -10°C to 60°C and have a mean time between failures of greater than 600,000 hr. 24 VDC power supply for the Pump Control Panel must be Model SDN-10-24-100P by Sola or approved equal.**

4.20.3.16. **Single Level Terminal Blocks. Provide terminal blocks in each control panel for terminating field wiring. Terminal blocks must be rated for 600 volts AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.**

Terminal blocks for 24vdc inputs must be blue.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-W4, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.17. **Two Level Terminal Blocks. Provide terminal in each control panel for terminating field wiring. Terminal blocks must be rated for 300 volts AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.**

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-JD3, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.18. **Three Level Terminal Blocks. Provide terminal blocks in each control panel for terminating field wiring. Terminal blocks must be rated for 300 volts AC and must be identified with a permanent**

machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-JT3M, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.19. **Fuse Holders. Provide fuse holders in each control panel as required. Fuse holders must be rated for 300 volts AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.**

Provide 20% spare fuse holders in the control panel.

Fuse holders must be Allen-Bradley Bulletin 1492-H6, equivalent by Phoenix Contacts, or approved equal.

4.20.3.20. **Grounding Blocks. Provide grounding blocks in each control panel as required. Grounding blocks must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.**

Provide 20% spare grounding blocks in the control panel.

Grounding blocks must be Allen-Bradley Bulletin 1492-JG3, equivalent by Phoenix Contacts, or approved equal.

4.20.3.21. **Wiring Ducts. Provide wiring ducts must be provided to manage path of wire and cable inside the enclosures. Provide-back wire retention to trap wires during installation. Ducts should meet a UL 94V-0 Flammability Rating, UL Component Recognized.**

4.20.3.22. **120VAC TV Surge Suppressors. Surge Suppressors must be Allen Bradley, or approved equal with the following features:**

- Max Surge Current: 40 kA/phase.
- Housing Rating: NEMA 4X, non-metallic enclosure.
- Connection Method: Parallel, #10 AWG Stranded Wire.
- Provided with thermal fusing.
- Diagnostics: Green Status LED, Audible Alarm.
- UL 1449 2nd Edition Listed.

Mount Surge Suppressor inside control panels.

4.20.3.23. **Alarm Lights. Alarm lights must be continuous intensity, amber, and sealed in a watertight enclosure. Alarm lights must be Patlite model PS-24 with a rubber gasket, equivalent by Phoenix Contacts, or approved equal.**

4.20.3.24. **General-Purpose Signal Multiplier. General-purpose signal multiplier must provide isolated input, 2 outputs, and power supply. Device must split the input signal into 2 output signals. The device must have the following features: DIN rail mounted; green power LED to indicate that the supply voltage is present; accepts #14-#24 AWG solid or stranded wiring; requires 18-30VDC power supply; and provides 4-20mA input and 2 sets of 4-20 mA outputs.**

General-purpose signal multiplier must be a Phoenix Contact MCR signal multiplier, equivalent by Allen Bradley, or approved equal.

4.20.3.25. **Industrial Backup PSTN and Leased Line Modem.**

- Modem must have the following ports:
  - One Public Switched Telephone Network (PSTN) Port
  - One Leased Line (LL) Port
  - One RS-422/485 Port
  - One RS-232 Port
- Modem must be rated for a temperature range of -13° to +158°F and relative humidity, non-condensing range of 5 to 95%.
- Modem must be designed to operate from 12 to 48 VDC or 12 to 27 VAC power source.
- Modem must provide data rates up to 33.6 kbits/s over both PSTN and 2- or 4- wire lease line circuits and data rates up to 115.2 kbits/s over the RS-422/485 and RS-232 protocols.
- The Industrial backup PSTN and Leased Line Modem must be Westermo TD-36 485, LV (Low Voltage) equivalent by Data Connect,or approved equal.

4.20.3.26. **Wiring. See Instrumentation and Control Wiring for supplemental information. Provide stranded copper, 14-gauge, 600 volt, Type MTW wiring. Power wiring must be 600 volt, Type MTW, sized as required. Splices are not permitted.**

Analog signal wiring must be 18 gauge twisted pairs with foil shield and drain wire, with 600-volt, 90°C insulation. Drain wires must be grounded at one end only.

Isolate wiring and terminal strips by voltage levels to the greatest extent possible.

Wiring must conform to the following color code:

- 120 volt, 1 phase: Black, White.
- 24 vdc: Blue.
- 120 VAC Control Wires: Red.
- Interlock control circuits energized from external source: Yellow.
- Ground Wires: Green.

120 VAC control wires energized from a source external to the control panel power source must be yellow.

Wiring for intrinsically safe circuits must be purple.

Tag control wiring at each end with a legible permanent coded wire-marking sleeve. Sleeves must be white PVC tubing with machine printed black marking. Markings must be in conformance with the wire numbers shown on the control wiring diagrams and must match terminal strip numbers.

In panels where foreign voltages exist, furnish a highly visible warning label outside the panel with the following words:

“WARNING: POWER FROM OTHER SOURCES EXIST IN THIS PANEL.
THEY ARE IDENTIFIED BY YELLOW WIRE COLOR.”

Warning label must be red with white lettering.

4.20.3.27. **Nameplates. Provide laminated phenolic nameplates on the front of each control panel. Nameplates must be black with white engraved letters. Engraving must be as indicated on the plans. Minimum size of engraving must be1/4 in.**

4.20.3.28. **Spare Parts. Provide the following spare parts.**

- 3 Selector Switches of each type and model specified and provided.

- 5 pushbuttons of each type and model specified and provided.
- 5 pilot lights of each type and model specified and provided.
- 3 Relays and associated sockets of each type and model specified and provided.
- 20 terminal blocks of each type and model specified and provided.
- 5 fuses and fuse blocks or holders of each type and model specified and provided.

4.21. **Instrumentation and Communication Wiring**. Provide electrical wiring needed to complete the Instrumentation Systems specified elsewhere in this Item and as shown on the plans.

Work covered by this section includes, but is not limited to, providing the following:

- Conduit raceways for signal cables
- Conduit raceways for AC power circuits
- Signal cables and coaxial cables
- Branch circuit (power) cables
- Terminal cabinets, junction and pull boxes
- Equipment connections
- Category 5e cable (Ethernet & Telephone)

Provide raceway systems, cables, and conductors from transmitters and sensing devices, etc. to instrumentation panels, terminal panels, etc. as shown on the drawings and specified in instrumentation and control divisions in the specifications or required by the equipment manufacturer.

4.21.1. **Submittals**. Submit shop drawings for the following:

- Terminal cabinets
- Power cables
- Signal cables
- Junction and pull boxes
- Category 5 cable

4.21.2. **Coordination**. Coordinate the work as specified herein with work to be performed and equipment furnished under other sections of this item to ensure a complete and satisfactory control and instrumentation installation.

4.21.3. **Wire and Device Coordination**. Label and number each wire around the wires at each termination of the wires at relays, terminal boards, and other devices. Use wire labels with a legible permanent coded wire-marking sleeve. Sleeves must be white PVC tubing with machine printed black marking. Wire numbers must correspond to wire numbers on the wiring and loop diagrams.

Identify cabinets and instruments by the same letter or number combinations used on the elementary wiring diagrams. Identification must be by means of white laminated Bakelite nameplates with 1/4 in. engraved black lettering. The nameplates must be fastened to the device or to the panel just below the device by stainless steel self-tapping screws.

In panels where foreign voltages exist, furnish a highly visible warning label outside the panel with the following words:

“WARNING: FOREIGN VOLTAGES EXIST IN THIS PANEL.
THEY ARE IDENTIFIED BY YELLOW WIRE COLOR.”

Warning label must be red with white lettering.

4.21.4. **Products**.

4.21.4.1. **General.**

- Wiring must be stranded copper.
- Wiring and terminal strips must be isolated by voltage levels to the greatest extent possible.
- Wiring must conform to the following color codes:
  - 120 volt, 1 phase: Black, White
  - 24 VDC: Blue
  - 120 VAC control wires: Red
  - Interlock control circuits energized from external source: Yellow
  - Ground wires: Green
  - 120 VAC control wires energized from a source external to the control panel power source must be yellow.
  - Wiring for intrinsically safe circuits must be purple.

4.21.4.2. **Terminal Cabinets. Terminals in cabinets, panels, etc. for instrument wiring must be miniature type with captive clamps to facilitate attachment of minimum size 14 AWG, rated for 600 volts. Terminals must have continuous marking strips.**

4.21.4.3. **Power Cables. Size power cables as shown on the plans and must be multi-conductor Type TC rated for 600 volts and must have crosslinked filled polyethylene or ethylene rubber insulation over Class B stranded copper conductor groups covered with overall polyester film type and with an overall thermoplastic jacket. (Coding must be ICEA, Method 1).**

4.21.4.4. **Signal Cables. Analog (4-20 mA) signal circuit wiring must be one, twisted shielded pair of 16 AWG instrumentation cable. Each tinned copper conductor, made up of 19 strands of 20 AWG wire must have color coded insulation. Two insulated conductors must be twisted together in an overall aluminum-polyester 100% coverage shield. Allow for 2 to 50 conductors per cable. Run cables run continuous without splices from transmitters to receivers or terminal cabinets. The shielded conductors, along with a stranded, bare 16 AWG drain wire must be rated at 600 volts; must bear the UL-TCER label as a recognized component of UR210. Each individual pair must be shielded and the entire multi-conductor cable must also be shielded.**

Digital signal cables must be multi-conductor twisted pairs. Conductor sizes and number of pairs must be as shown on the drawings or as required by the manufacturer of the signal equipment. Must allow for 2 to 50 conductors per cable. Run cables continuous without splices from transmitters to receivers or terminal cabinets. Cable must be multi-conductor THWN UL-TC-ER wiring.

4.21.4.5. **Communication Cables. Profibus Cabling must be 600V UL-TC0-ER IS/OS 2118A cabling with gauge size and pair count as required. Modbus RTU cabling must be 3 and 4 wired version as necessary to provide a complete and fully functional system.**

Connections between PCs, Modbus devices, Profibus devices, network switches, and control network must be made using Category 5e Shielded Twisted Pair solid cable with PVC jacket and shielded RJ-45 connectors, unless otherwise specified. Use shielded Twisted Pair stranded cable for those links that may be subjected to repeated flexing.

Meet the following requirements:

Wiring Type:	Category 5e, TIA/EIA 568C
Impedance:	100 +/- 15 Ohms
Conductor Gauge	24 AWG
Cable construction:	4 pair, PVC jacket, solid or stranded conductors.
Connectors:	RJ45, shielded
Frequency:	Up to 1 GHz

Shield:	Copper braid, covering 4 pairs and connectors. Shield connected to external drain wire.

Cat 5E cables must be DataTuff Cat 5e 600V AWM-rated Cable by Belden, Square D, or approved equal.

Provide factory terminated cables, except as listed below. Maximum length is 300 ft. For communication links of greater lengths, use fiber with appropriate switches and media converters. Field terminated (bulk) cable is only permissible for the following:

- Cables terminated on terminals of field instrument or control devices, or
- Cables that leave a building

Telephone Cables: Provide Category 5E Cable with RJ-45 connectors for telephone applications where specified.

4.21.5. **Execution**.

4.21.5.1. **Grounding. Ground wires in conformance per requirements of the Electrical Specifications.**

4.21.5.2. **Installation of Wire and Cable. Install wire and cable per requirements of Electrical Specifications.**

Shield Grounding: Each signal shield must have only one grounding point which must be located at the source of the signal, (e.g. analog transmitter) unless otherwise recommended by the instrument or equipment manufacturer. Shields must be continuous through cabinets, panels, etc.

Terminations: Terminate wire at both ends of the power and signal cables with pre-insulated solderless spade or ring lugs and in conformance with the requirements of the Control Panel Specification. Spare conductors must be terminated on marked terminal strips or connector pins at each end.

Only pull wires and cables once. Wires and cables which are pulled in one direction and retracted, must be replaced with new wires and cables at no additional cost.

No splices will be permitted.

4.22. **Process Control Strategies**.

4.22.1. **Panel Description**. Provide a pumping system consisting of a motor control center (MCC), variable frequency drives (VFD), station Pump Control Panel (PCP), reduced voltage solids state starters (RVSS), primary transducer, secondary back-up floats, signal booster-duplicator (SB), programmable logic controller (PLC), local control stations, existing remote telemetry unit (RTU), level Control Panel (LCP), manufacturer packaged pump controllers (PPCs) for the pumping station.

Manufacturer Packaged Pump Controllers (PPCs): PPCs must be provided by the pump manufacturer. Separate PPCs must be provided for the sludge pump and main storm water pumps: SWP-1 and SWP-2, SWP-3, and SWP-4. The PPCs must control and monitor the provided pumps. Manufacturer PPC must be provided with integral operator interface terminals and communicate with local hand stations for LOCAL/OFF/AUTO interlocks.

Provide a separate local control station enclosure for the sludge pump PPC.

Locate the PPCs for the main storm water pumps, SWP-1, SWP-2, SWP-3, and SWP-.4, in the station Pump Control Panel (PCP).

Provide a Level Control Panel (LCP) to aggregate and duplicate field analog 4-20 mA and discrete level indications. The LCP must communicate level information to the sludge pump PPC, main storm water pump(s) PPC, and PLC located in the station PCP.

4.22.2. **Station Pump Control Panel (PCP)**. Provide a station PCP with a PLC to communicate with the following.

- Main Storm Water Pump PPC
- Sludge Pump PPC
- Human Machine Interface (HMI)
- SWPS: 1, 2, 3, and 4 VFD/SSRVS
- Level Control Panel
- Generator
- Automatic Transfer Switch
- Building Security
- Fire Alarm
- Intrusion Switches
- Existing RTU
- MCC

Provide the PLC with input/output (I/O) modules to communicate via digital-discrete, analog, ethernet, modbus TCP as necessary to communicate with the equipment and location. Final determination of equipment and communication protocol must be the responsibility of the Systems Integrator.

Provide a PLC manufactured by Allen Bradley, Schneider Electric, or approved equal.

The PCP must have primary and backup communications with the pumping system manufacturer PCPs. Primary communication must be high-speed communications via Modbus/CATe. Back-up communications must be hardwired analog and discrete signals. Upon loss of primary communication, the PLC must automatically use hardwired I/O.

Existing Remote Terminal Unit RTU: The Systems Integrator must evaluate the existing RTU to determine its suitability for reuse. The Systems Integrator must be responsible to expand or modify the existing RTU I/O platform to communicate with the new PCP and the existing TxDOT SCADA system. Evaluation must include, but not limited to, evaluating and replacing the enclosure, power supplies, I/O cards, modemed, power supplies, switches, communication cards, network switches, relays, and applicable appurtenances necessary to meet the requirements of the plans and specifications.

4.22.3. **Pump Station Control Panel**. Supply a pumping station control panel (PCP) in the pumping station control room to house manufacturer packaged pump controllers (PPCs) a programmable logic controller (PLC), human machine interface (HMI) / operator interface terminal (OIT), digital displays, and other associated controls for the pumping station equipment. The PCP must provide automatic control, process, and alarm monitoring for the station Operator Interface.

Provide 15 in. PCP and Sludge Pump HMI/OIT Control Panels manufactured by Harmony GTU, Magelis GTU, or approved equal. Supply HMI/OIT will necessary HMI software, drives, and other development tools to provide a complete and functional system in conformance with the plans and specifications.

Mount the PPC programmable operator interface on the pumping station control panel. Provide a standalone enclosure for the sludge pump PPC. Program the operator interface to perform the following functions:

- Display Graphic Screens of the Pumping Station
- Display Process Variables
- Display Alarm Messages
- Display Setpoint Screens
- Trend Wet Well Levels

- Trend Pumping Station Flows

The operator interface must be a color touch screen, which must be networked to the PLC system via Ethernet.

4.22.3.1. **Programmable Controller Software. Programmable controller programming and documentation software must be provided to enable a workstation to be used to view, edit, program, document, and communicate with the PPC's and station PLC.**

4.22.3.2. **General Systems Requirements. The complete pumping control system must be provided by the pump manufacturer. The pumping manufacturer must be responsible for coordination and communication to provide a complete and functioning system in conformance with the plans and specifications.**

The PPC's must have independent, field adjustable, level control set points for each pump start and stop and alarm notification set points. The PPC must control the pump station using the water level measured by the Primary Level Transducer unless one of the following alarms occurs:

- Low Water Level Alarm is triggered via the Primary Level Transducer analog signal and associated set point within the PPC.
- High Water Level Alarm is triggered via the Primary Level Transducer analog signal and associated set point within the PPC.

If one of the above alarms occurs, the level control for the pump station must switch to operation via the back-up float system. The PPC must continue to use the back-up float system for level monitoring and control until the Primary Level Transducer is re-enabled by pressing the "Reset" pushbutton on the Pump Control Panel.

In the back-up float mode of operation, the VFD must operate at the operator selected speed or full speed if in SSRVS Mode.

If either the Low-Level Float or the High-Level Float are triggered and maintained for set periods of time during any of the operational modes detailed above the PCP must trigger a common alarm and enter the Backup Relay/Float operation mode. In this mode the PPC will start and stop the mains stormwater pumps via hardwired control logic and will no longer use the PLC or Level Transducer for station operation or control.

Backup Relay/Float operation must use hardwired time delay relays and must operate independently of the PPC. This mode of operation extends to failure in the PCP. Backup Relay/Float operation must function as follows.

The PCP must contain a time delay relay for each of the four pumps. Upon initial triggering of the high-level float, the time delay relays must be energized. As an individual float is triggered and the associated field configurable delay time relay has elapsed, the PCP must start the pump. The time delays must be initially configured to allow individual, sequential starting of the pumps.

Following deactivation of the high-level float, pumps that were called to run must remain running until the individual float is no longer triggered. Pumps must have an adjustable restart timer applicable in all modes of operation.

- When the low-level Float is triggered, pumps must be called to stopped under operational modes such as Back-Up Relay/Float, Primary Level transducer, and PPC, operational modes.
- Back-Up Relay Float mode must only be applicable for the main storm water pumps.

Any station alarm can be disabled at the station through the local HMI. The alarm disable function must be password protected so that only designated personnel can disable the station alarms. When there is an alarm present at the station it must be displayed on the OIT screens.

The PPC must have an output that will be energized any time there is an alarm present at the station.

Install 1 Primary Level Transducer to sense the level in the wet well and provide automatic control of the pumps. The Transducer must output a 4-20mA analog signal proportional to the wet well level to the PCP and PLC for level monitoring.

Install Backup Relay/Floats in the wet-well for automatic control of the pumps independent of the PPC.

4.22.3.3. **Pump Motor Controls. The pump motor controls should include the following.**

- A variable frequency drive (VFD) and reduced voltage solid state starter must be provided for each of the main storm water pumps. The VFD will be the primary mode of operation. The Operator must manually select the SSRVS mode of operation at the MCC.
- An embedded VFD and manufacturer provided PPC must be provided for the sludge pump.
- The AUTO position of each pump H/O/A selector switch must be wired to allow for remote starting of the pump via the MCC.
- Each pump H/O/A switch must have an auxiliary normally open contact that must close when the switch is placed in the AUTO position. This contact must be wired to the PPC.
- Each VFD and RVSS must have a run contact that must close when the starter is energized and providing power to the pump motor. This contact must be wired to a run indication light and elapsed time meter on the MCC enclosure, and a run relay located inside the enclosure.
- Each VFD and RVSS must have a fault contact that must be wired as an input to the PPC.
- The run status and fault alarm for each VFD and RVSS must be input to the PPC.
- Lock-out stop push buttons (maintained type) must be on the station PCP enclosure or where shown on the plans. The stop buttons must be wired in series with the pump control circuit so that when a stop button is pushed in, power to the control circuit must be disconnected.

4.22.4. **Description of Operation**. The pumps must be controlled by the individual H/O/A selector switches located on the MCC, PCP and Local Station. The HAND and OFF positions of the H/O/A selector switches provide for manual start/stop control of the pumps. In the HAND position, the pump start sequence must begin. In the OFF position, the pump stop sequence must begin.

When the pump H/O/A switches are in the AUTO position, the pumps must be automatically started and stopped by the PPC in response to the wet well level as follows:

Program level setpoints in main storm water pump PPC for the following levels.

- Wet Well High-Level
- Lead Pump Stop
- Lag 1 Pump Stop
- Lag 2 Pump Stop
- Lag 3 Pump Stop
- Lead Pump Start
- Lag 1 Pump Start
- Lag 2 Pump Start
- Lag 3 Pump Start
- Wet Well Low-Level

Program level setpoints in sludge pump PPC for the following levels.

- Sludge Pump Stop
- Sludge Pump Start
- Wet Well Low-Level

The level setpoints must be adjustable via the operator interface located in the main storm water pump and Sludge Pump PPCs

Program the operator interfaces to enable the Operator to select whether the pumps must be controlled by the primary transducer or secondary back-up floats.

Any Mixed Flow Axial Impeller Pump can be selected as the Lead or Lag 1-3 in Lead-Lag sequence.

The pump alternation must be based upon selection of the Lead or Lag 1-3 pumps.

The Operator must select the Lag pump order from the operator interface. Any pump must be able to be assigned to any position in the operational door.

The Operator must select the mode of alternation from the operator interface. The three alternation modes are Lag Pump Alternation, Time Alternation, and Manual Alternation.

4.22.5. **Process Control Strategy**. When the level in the wet well rises to the elevation of the Sludge Pump Start level setpoint, the PPC must start the Sludge Pump. When this level is reached, a start delay timer in the PPC should start. When this timer times out, the PPC must start the Sludge Pump.

If the Sludge Pump cannot keep up with the influent flow, the level in the wet well must rise to the Lead Main Pump Start level set point. When this level is reached, a start delay timer in the PPC must start. When this timer times out, the PPC must start the Lag Main Pump. If the level is above the Lead Main Pump Stop level, the Lead Main Pump and Sludge Pump must run continuously.

The operating pumps should be lowered to minimum speed before starting an additional pump. Start the called pump at minimum speed and the Lead and Lag-1 pump speeds will be increased simultaneously to mitigate surges in downstream flow.

If the Sludge Pump and Lead Main Pump cannot keep up with the influent flow, the level in the wet well will rise to the Lag-1 Main Pump Start level set point. When this level is reached, a start delay timer in the PPC must start. When this timer times out, the PPC must start the Lag-1 Main Pump. If the level is above the Lag-1 Main Pump Stop level, the Lag Main Pump, Lead Main Pump and Sludge Pump must run continuously.

The operating pumps should be lowered to minimum speed before starting an additional pump. Start the called pump at minimum speed and the Lead, Lag-1, and Lag-2 pump speeds will be increased simultaneously to mitigate surges in downstream flow.

If the Sludge Pump, Lead, and Lag-1 Main Pumps cannot keep up with the influent flow, the level in the wet well will rise to the Lag-2 Main Pump Start level set point. When this level is reached, a start delay timer in the PPC must start. When this timer times out, the PPC must start the Lag-2 Main Pump. If the level is above the Lag-2 Main Pump Stop level, the Lag-2, Lag-1, and Lead Main Pump and Sludge Pump must run continuously.

The operating pumps should be lowered to minimum speed before starting an additional pump. Start the called pump at minimum speed and the Lead, Lag-1, Lag-2, and Lag-3 pump speeds will be increased simultaneously to mitigate surges in downstream flow.

If the Sludge Pump, Lead, Lag-1, and Lag-3 Main Pumps cannot keep up with the influent flow, the level in the wet well will rise to the Lag-3 Main Pump Start level set point. When this level is reached, a start delay timer in the PPC must start. When this timer times out, the PPC must start the Lag-3 Main Pump. If the level

is above the Lag-3 Main Pump Stop level, the Lag-3, Lag-2, Lag-1, and Lead Main Pump and Sludge Pump must run continuously.

When the level in the wet well is pumped down to the Lag-3 Main Pump Stop level set point, the PPC must shut down the Lag-3 Pump at minimum speed.

When the level in the wet well is pumped down to the Lag-2 Main Pump Stop level set point, the PPC must shut down the Lag-2 Pump at minimum speed.

When the level in the wet well is pumped down to the Lag-1 Main Pump Stop level set point, the PPC must shut down the Lag-1 Pump at minimum speed.

When the level in the wet well is pumped down to the Lead Main Pump Stop level set point, the PPC must shut down the Lead Pump at minimum speed.

When the level in the wet well is pumped down to the Sludge Pump Stop level set point, the PPC must shut down the Sludge Pump.

For each pump, the current number of starts and current runtime hours must be calculated in the PLC for the current 24-hr. period. These values must roll into yesterday's number of starts and yesterday's runtime hours after the current 24 hr. period expires.

When the PLC senses a loss of power, it will remove the run signal to the pumps after a time delay that is set at the OIT. When the power returns, the pumps will start one at a time. There will be a time delay for each pump start so that the pumps are staggered on a restart. These delay times must be set from the OIT.

When the PLC senses a blip in power, it will remove the run signal to the pumps. After a time delay that is set at the OIT and the pumps are in the ready state, the pumps will start one at a time. There will be a time delay for each pump start so that the pumps are staggered on a restart. These delay times must be set from the OIT.

If the level in the wet well is drawn down to the Wet Well Low-Level setpoint, a timer in the PPC must be started. If this timer times out and the Low-Level condition still exists, the PPC must shut down all pumps. When this occurs, a Wet Well Low-Level alarm message must be displayed on the operator interfaces. This condition must also cause the Back-up floats to take control of the station as previously described.

If the level in the wet well rises to the elevation of the Wet Well High-Level setpoint, a timer in the PPC must be started. If this timer times out and the High-Level condition still exists, a Wet Well High-Level alarm message must be displayed on the operator interfaces.

The PPC's must provide failure monitoring for each pump as follows.

When a pump H/O/A switch is in the AUTO position and the pump gets signal to start, a failure timer in the PLC's must start. If this timer times out and the pump VFD or across the line starter is not running, a "Pump Failure" alarm message must be displayed on the operator interfaces.

If a pump is taken out of AUTO or experiences a failure or fault, the PPC's must index the lead or lag assignments of the pumps so that this pump is moved to the LAG position. The failed pump must be locked out of the pump sequence until it is placed back in AUTO or its alarm has been cleared.

The following alarms for each of the pumps must be displayed on the operator interfaces located on the control panel:

- Pump Overload
- Pump Not In Auto
- Pump Fail to Start

- Pump Over Temperature
- Pump Seal Failure
- 3.7 POWER MONITORING
- General Description
- TVSS device must be provided for the Pump Control Panel to protect the system from transient voltages that may occur due to lightning or surges on the incoming power line. Description of Operation:

Furnish TVSS devices with a normally open alarm contact. This contact must be wired to the PLC. If a TVSS alarm occurs, this contact must close, and a TVSS Alarm message must be displayed on the operator interfaces.

4.22.6. **Uninterruptible Power Supply (UPS)**. Furnish a UPS with a normally open contact that must close when the UPS is operating on battery power. This contact must be wired to the PLC's. When normal power fails and the UPS is operating on battery power, a timer in the PLC should start. If this timer times out and the UPS is still on battery power, a "UPS on Battery Power" alarm message must be displayed on the operator interfaces located on the pumping station control panel.

Furnish a UPS with a normally open contact that must close when the UPS battery power is low. This contact must be wired to the PLC. If the battery power becomes low, a timer in the PLC must be started. If this timer times out and the UPS battery power is still low, a "UPS Battery Power Low" alarm message must be displayed on the operator interfaces.

Furnish 120V UPS units for the Pump Control Panel and the Sludge Pump Control Panel. Size the units to provide 1 hr. of operation at full load, with alarm contacts to indicate when the UPS is operating on battery power and when the UPS has failed or requires maintenance. Alarms must be monitored by the PLC.

4.22.7. **Operator Interface**. Mount a programmable operator interface on the control panel to display alarm messages and process values and to enable the operator to change process setpoints in the PLC.

Whenever an alarm occurs, a corresponding alarm message must be displayed on the operator interface as previously described in the description of operation. If more than one alarm is present, the alarm messages must scroll with each message being displayed for 3 seconds.

An alarm message must remain in the system until its corresponding alarm is cleared.

4.23. **Process Control and Instrumentation for Sludge Pump–Manufacturer Packaged Pump Controller (PPC)**. The pump manufacturer must provide a control panel for the Sludge Pumping System. This system will include, but is not limited to, the following.

- Communications gateway for each Pumping System (CPS)
- Pump station controller capable of controlling sludge pumps with integral pumps
- Remote monitoring equipment compatible with the manufacturer's remote monitoring system
- Surge protection
- Automatic Pump Cleaning
- Pump Blockage
- Time Based Pump cleaning
- Modular expansion and configuration
- Commissioning of the control panel
- Site acceptance testing (SAT)

4.23.1. **References**.

- UL 508A and 698A
- NFPA 70 - NEC (2017)

- NFPA 820
- ISA 5.1 and 5.4
- ISA/IEC 62443-4-1
- ISA/IEC 62443-4-2
- IEC 60870–5 104

4.23.2. **Submittals**. Submittals must include but are not limited to the following:

- Shop drawings
- Bill of Material (BOM)
- Wiring diagrams
- Outline and dimension drawings
- Enclosure mounting details

4.23.3. **Delivery, storage, and handling**. Deliver, store, protect and handle products to the site under provisions of this Item. Store in a clean, dry space. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

4.23.4. **General requirements**. The Pump System manufacturer must design and build the control panel.

4.23.5. **Installation**. Installation must be in conformance with manufacturer's instructions. Perform electrical work performed full conformance to the requirements of the Electrical Specifications.

4.23.6. **Warranty**. When installed in conformance with the provisions of this section and related sections, the warranty against defects in materials and or workmanship on the control panel must be 7 yr. (84 months) from Completion Substantial. The warranty must be in printed form, included with the product submittal, and previously published as the manufacturer's standard warranty for similar units manufactured.

4.23.7. **Products**.

4.23.7.1. **Monitoring and Control Products.**

Pumping System Controller (Nexcon, Miltismart, or Approved Equal). The station controller must have the following features, at a minimum:

- Hand-off auto switch for each Pumping System (CPS)
- User configurable liquid level setpoints for CPS activation and deactivation.
- User configurable liquid level alarm setpoints for high level..
- Alternation options include: Lead and Lag.
- Inputs and outputs
  - 4 zero-volt digital inputs
  - 4 relay outputs rated at 250V or 30VDC, 5 amps .
  - 1 analog input 24VDC max
  - 1 analog output 24VDC max.
- Sludge Pump Modules. Provide modules as necessary to provide functionality and communication as described on the plans and specifications.
  - Set power, set speed, and displayed current.
  - Automatic start when the power is turned on.
  - Soft start and stop.
  - Energy minimizer.
  - Pipe flushing at pump cycle start.
  - Automatic pump cleaning
  - Pump blockage

- Time based pump Cleaning
- Dry run protection
- Leakage and overheating protection
- Motor protection

At a minimum, provide a pump control system with the following modules:

- Sludge Pump modules
- VFD module
- Backplane supply modules
- Probe module
- Digital I/O
- Analog I/O
- Station Manger
- Security

The following station optimization features must be pre-configured:

- Fat buildup minimization feature that uses a random lead pump start delay timer. The timer should be initially set to 60 seconds.
- A sump and pipe cleaning function that will run the CPS to the snore point based on an operator configurable number of pump cycles. The number of cycles must be initially set to 11.
- The CPS must automatically detect a blockage and automatically clear the blockage. The station controller must monitor the status and annunciate an alarm should the blockage not be cleared.
- The station controller must have an energy minimizer function that minimizes the amount of energy used per pumping cycle.
- Integrated data logger with
  - Capacity for recording up to 4,000 events
  - Ability to download events to a USB storage device
- Monitoring of output current, power level, speed, and motor temperature
- Faults on the controller must be configurable for
  - Acknowledgement Required
  - Three (3) levels of priority
  - Automatically resetting fault
- Human Machine Interface (HMI). A display compatible with the pump station manager and must have the following features at a minimum:
  - Home screen displayed parameters must include:
    - Pump status for each pump including:
    - Pump running.
    - Pump is in the HAND position.
    - Pump is in the OFF position.
    - Pump is in the AUTOMATIC position.
    - Pump is available to run.
    - Pump fault
  - Pump alternation active indicator.
  - High inflow control

Information Screen that shows the following information:

- Hours Run counter for each pump:
  - total time today, total time yesterday

- total time this week
- total accumulated hours since last commissioning

- Pump Start counter for each pump:
  - pump starts today, pump starts yesterday
  - pump starts this week, total accumulated pump starts
  - power in kW
- I/O Status
  - Digital I/O status
  - Analog I/O status with a value in (mA)

Ability to configure the controller without a laptop and configure the following parameters at a minimum:

- Set point programming of pump activation/deactivation values and level alarm values.
- Enable/Disable level alarms, faults, and historical data recording.
- Configuration of Inputs and Outputs.
- Configure station optimization parameters.
- Configure communications parameter.
- Create or restore backup copies of the pump controller configuration settings.
- Factory reset the controller.

Supply a 7 in. touchscreen display, instead of, or in conjunction with the keypad display, with the following features at a minimum:

- Built in web browser
- Multi-touch screen
- Dual core process @ 8MHz
- 512 MB Flash and 1GB Ram
- Fan-less design
- IP65 front panel
- Power: 12-24VDC @8.5W
- Resolution: 800x480
- Operating temperature: 0-60C

Pumping system gateway

- Each pump must be equipped with 1 Pump gateway which must offer at least following interfaces: 1 x USB, 1 x RS485 1 x Ethernet RJ 45 1 x Display interface, 4 x Digital outputs, 4 x Digital inputs, 1 x Analog input & output.
- It must supply the following pump data:
  - Start and stop commands
  - Power consumption information
  - Operating speed
  - Running status
  - Fault information
- The housing must be isolated according protection class IP 20 applicable to operate in ambient temperature: -20 ˚C to +60˚C.
- It must be applicable for 24 V DC Power supply.
- The pump gateway must allow to control of the pump through I/O or Modbus RTU or TCP.
- It must have emergency run relay functionality which secures that the pump will operate when the main controller fails.
- The unit must be tested and approved in conformance with international standards CE, UL, RCM and CSA and be designed and manufactured by the pump supplier

4.23.7.2. **Level Sensor. The sump must be equipped with a Multi-Stage Level Sensing device or a Level transmitter designed to detect level of the wastewater for pump control and liquid level display. Provide a Flygt LTU 801 sensor, equivalent by Endress and Hauser, or approved equal.**

The Multi-Stage Level Sensing Device must be PVC injected to seal the unit and prevent any moisture from entering any of the sensor units. Each sensor on the probe must be rotated 90 degrees horizontally from the previous sensor along the probe length to eliminate tracking between sensors. Level sensing probes must be pressure injected with an epoxy resin at final assembly to encapsulate internal components and connections, thereby creating a rigid, sealed, homogeneous unit. Include two wires within the length of the probe, connected to each other at the bottom of the probe. When the wires are connected to the Pump station controller, the connection must provide fail-safe monitoring of the probe cable and the probe assembly. The flexible cable used for the Level Sensing Probe must be comprised of PVC/PVC multi-conductor construction with a common oversheath that is water and oil resistant. Identify the multi-conductor cable with numbering and text along the entire length of the outer sheath at required intervals.

The Level transmitter must measure the relative pressure with a ceramic diaphragm and be approved acc. EN 61000-6-2, EN 61000-6-3, EN 61326-1. It must be insulated > 100 MΩ at 500 V DC and the sensor body must be made of Ryton PPS.

The sensors installed in the sump must be approved for explosive areas according UL Class 1, 2 and 3 Division 1 Group A-D T4/T5/T6

Cables must be secured to the top of probe bodies by synthetic rubber compression fittings for strain relief. The cable must be rated to physically support the combined weight of the sensor and long enough to reach to reach the cable connection box.

Provide a stainless-steel mounting that includes a wiper device that allows maintenance personnel to clean the level sensing probe when necessary.

4.23.7.3. **Float Switch. Provide a cable float switch suitable for indoor or outdoor installation. It must be capable of operating automatically to indicate tank level, start or stop pumps, or actuate level alarm signals.**

The float switch and piping must be submersible. Provide a junction box near the float to allow for easy removal and replacement. The junction box must a minimum NEMA 4X and float switch must be IP 68 rated. The components must be listed as suitable for the hazardous area classification where they will be installed. Construction must have materials compatible with the application. For floats installed in process areas, do not locate the Junction box in the wet well or process area.

Ensure that the float switch and cable are properly mounted and that the float switch is secured and there are no obstructions within the tank to prevent full extension of the cable in either direction. Provide adequate designed 316 stainless steel pole or stainless steel weighted chain and weight for float to allow for removal, replacement, and adjustment of the floats without entering the tank and to allow for secure mounting in the tank or process area during operating conditions.

Provide a complete float switch system including, but not limited to, sensor, cable, enclosure, power supply intrinsic safety barrier, signal conditioner, pipe mount clamps, and other hardware and accessories as required by the manufacturer for a complete and fully functional system.

Provide, install, program, and calibrate each float switch system in areas shown on the plans and specifications. Ensure that instruments are tagged and calibrated in conformance with PID diagrams, the instrumentation layout, and individual equipment specifications.

- Type: Mercury free ball float switch
- Function and Performance:

- Differential: Switch must activate when the process level rises to no more than 4 in. above the fixed mounting position and deactivates when the level decreases to no more than 4 in. below the fixed mounting position.
- Switch Rating: 1 amp at 120 VAC or 100 VA at 120 VDC.
- Provide NO or NC type contact for fail safe operation.

■ Physical:
- Float: 316 stainless steel, with Teflon or non-stick coating, minimum 5-in. diameter.
- Totally encapsulated switech.
- Cable must be heavy duty, PVC, or equivalent jacketed integral to float.

■ Accessories required:
- Provide stainless steel hardware.
- Lead wire must be a waterproof cable of enough length so that no splice of junction box is required in the vault.
- Provide cast-aluminum weatherproof junction box outside the sump pit with terminals for all floats and tapped as required for conduit connections.

■ Manufacturer's: Siemens Water Technologies, Contegra, or approved equal.

4.23.7.4. **Backup UPS system. Provide a 24VDC power supply with battery backup capable of running al DC loads for a minimum of 1 hr.**

4.23.7.5. **Surge suppression. Supply a 240VAC or 480VAC three-phase surge suppression device installed in line with the supply voltage with the following features:**

■ Each input must have a nominal AC operating voltage of 240V for 240V supply or 277V for 480V supply
■ Meet UL 1449 4th edition requirements
■ Meet IEC 61643-11 requirements
■ A response time of less than 1 ms
■ Nominal discharge current: 20kA 8/20 µs
■ Maximum discharge current: 50kA 8/20 µs
■ Maximum surge capacity: 60kA 8/20 µs
■ Voltage protection rating: 1000V (240V) or 1500V (480V)
■ Voltage protection level: 1300V (240V) or 1700V (480V)
■ Residual voltage at 10kA (8/20 µs): 1395V
■ Operating frequency range: 0-500Hz
■ Operating temperature: -104ºF to +185ºF

4.23.7.6. **Hazardous Location Protective Device. The Hazardous Area Protective Device is intended to protect equipment and personnel in areas where hazardous conditions may be present.**

Supply an intrinsically safe device according to the following specifications:

■ The intrinsically safe barrier must be panel mounted and designed to protect a ball float inputs and level transducer inputs.
■ The barrier must be certified intrinsically safe for use with equipment in installations up to and including Class 1, Zone O.
■ The intrinsically safe barrier must have screw terminals for wire connections.
■ The intrinsically safe barrier must be protected and current limited according to the requirements of UL Class I (Groups A, B, C & D), Class II (Groups E, F, & G) and Class III certification.
■ The device must also be CE and CSA listed for applicable locations and must allow a maximum short circuit current of 10 ma.
■ The intrinsically safe barrier must be surface mounted using the mounting flanges on either side of the unit assembly.

- The unit must be fastened with approved screws or bolts in conformance with UL requirements.

4.23.7.7. **Control Panel Construction & Assembly. Control panels must be manufactured in accordance with the UL 508 standard or UL 698A and must be so constructed for the application of a UL listing label by an approved UL control panel assembly facility.**

Install and arrange the control panel wiring must in an organized, efficient manner. Inspect control panel wiring for safety and verified by performing a point-to-point test.

Properly inspect and torque electrical connections in compliance with the UL 508 standard or UL 698A standard. External connections to the control panel must be by way of numbered terminal blocks.

Properly check and load test control panels with power applied. A control panel test log must be supplied with the control panel.

Provide control panels from a UL approved control panel assembly facility with the required labels properly attached.

Control panel enclosure environmental rating: Control panel enclosure rating must be specified in conformance with the project requirements or the plans as either NEMA 12 (painted steel) or 4x (stainless steel).

Wiring requirements:

- Wiring for AC and DC control circuits must be Type SIS or Type MTW stranded copper and must be sized for the applied voltage and current. Unless otherwise noted, control circuit wiring must not be smaller than No. 16 AWG.
- Cable wiring for analog signal circuits must be twisted, shielded pairs of stranded copper conductors that must not be smaller than no. 20 AWG.
- Wiring for special signaling equipment such as communications, digital data, and multiplexed signals must be provided by the equipment supplier.
- Wiring must be numbered and marked at each termination point.
- Terminal blocks for internal or external wiring must be din rail mounted, individual screw compression type terminals with machine printed labels.

Grounding. Properly ground panel enclosure in conformance with the national electrical code and local code requirements.

Each analog signal loop must only have its shield wire connected to ground at a single point for the loop. Shields must be grounded at control panels where signals are input to the receiving device and not at the source of the transmitting device.

Local alarm (flashing light). There must be a flashing alarm light mounted on top of the control panel enclosure for local alarm indication. The flashing alarm light must be supplied according to the following specifications:

- UL recognized for use with UL NEMA type 4x &12 enclosures.
- Shatter resistant Lexan globe, UV Stabilized and flame retardant.
- The flashing alarm light must be by Ingram products, equivalent by Phoenix Contacts, or approved equal.

Electrical transient (surge) protection. Protect electrical and electronic components of the control panel against damage due to electrical transients induced in interconnecting lines from lightning discharges and surges in nearby electrical systems.

The transient surge protector must be rated for 25ka per phase or larger.

Enclosure condensation heater. Provide a 120vac, 100-watt enclosure heater inside the control panel. The heater must be a silicone rubber, insulated strip type enclosure heater. The heater must be Hoffman, Hammond, or approved equal.

4.23.8. **Execution**. Perform installation in conformance with plans, specifications, and manufacturers specifications.

4.23.8.1. **Examination. A factory trained technician must examine the work area before beginning work and check the following:**

- The environment is safe to work in.
- Surfaces are ready to receive work.
- Tools are in the proper location and are in good condition.
- The system is grounded.

4.23.8.2. **Field Quality Control. The following field tests must be performed by a factory trained technician.**

- Point to point wiring verification
- Utility power verification
- Site acceptance testing
- System demonstration

Point to Point I/O Verification. After installation of the pumps and the control panel, a factory trained technician must prepare the I/O checklist. The checklist must include the following:

- Inputs and outputs are connected to the control panel
- Alarms can be generated by the control panel
- The technician must follow a test procedure to test I/O and alarms.
  - Test digital inputs from point of origin unless it is unsafe.
  - Test digital outputs by running a simulation test from the controller or by simulating the fault condition.
  - Test analog inputs from the point of origin where possible and by use of a signal generator otherwise.
  - Test analog outputs by running a simulation program or by forcing the output to a value.
- The technician must follow a test procedure to ensure the system operation parameters are met.

Configuration Verification. The factory trained technician must document the settings using a factory provided configuration checklist. Each parameter must be verified before the start of testing and then again after testing is completed.

Document the configuration of the pump station manager as well as the IPS gateways.

Save the pump station manager configuration to a factory provided SD card after testing is completed.

4.23.8.3. **Factory trained Supervision.**

- Procure a factory trained technician to check over equipment before putting the equipment into operation.
- Perform a point-to-point test of wiring.
- Perform a functional test of equipment alarms and controls.

4.23.8.4. **Certification of Testing.**

- Perform tests in the presence of a duly authorized representative of the Department. If the presence is waived, certified results must be provided by the Contractor.

- Provide written notice of tests two weeks in advance of testing.

4.23.8.5. **Test Equipment. Test equipment must be provided by the Contractor.**

4.23.8.6. **Training. Training must be a minimum of 4 hr. and cover the complete Pumping System and related controls. Provide instruction material for 4 trainees.**

4.24. **Pump Control System for Main Storm Water Pump–Manufacturer Packaged Pump Controller (PPC)**. A packaged pump control controller must be provided by the pump manufacturer for the main storm water pumps. The packaged pump controller must be provided as part of the Pump Station Control Panel. The complete system must be coordinated by the pump manufacturer to provide a complete and functioning system.

Furnish and place into operation the monitoring and control panel a pump station with submersible column pumps as shown on the drawings.

The controller must alternate the pumps and operate the pumps always at its best efficiency.

4.24.1. **References**.

- Electrical work must be in conformance with Electrical requirements as specified and shown
- UL 508A and 698A
- NFPA 70 – NEC (2017)
- NFPA 820
- Canadian Underwriters Laboratory (CUL)
- ISO 9001 and ISO 140001

4.24.2. **Submittals**. Submittals must include but not be limited to the following:

- Shop drawings
- Bill of Material (BOM)
- Wiring diagrams
- Outline and dimension drawings
- Enclosure mounting details

4.24.3. **Delivery, storage, and handling**. Deliver, store, protect and handle products to site under provisions of the plans and specifications. Store in a clean, dry space. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

4.24.4. **Qualification requirements**. The manufacturer must provide data on alternate equipment manufacturer's experience. Only Manufacturers with 20 or more years of experience who have furnished at least 20 similar lift stations that have been in regular operation not less than 5 yr. will be considered. Evidence of experience and operational data may be required from the manufacturer to determine the suitability and efficiency of the equipment offered.

4.24.5. **Installation**. After installation, perform a pump station start-up by the installing contractor under the supervision of the manufacture's authorized representative. Field service must be provided by an authorized, factory trained representative of the pump manufacturer. Services must include, but not be limited to, inspection of the completed pump station installation to ensure that it has been performed in conformance with the manufacturer's instructions and recommendations, supervision of field-testing and activation of the Pump Manufacturer's Warranty. The test must demonstrate to the satisfaction of the Department that the equipment meets specified performance criteria, is properly installed and anchored, and operates smoothly without exceeding the full load amperage rating of the motor. Be responsible for coordinating the required field services with the Pump Manufacturer.

Perform electrical work in full conformance to the requirements of the Electrical Specifications and plans.

4.24.6. **Warranty**. When installed in conformance with the provisions of this section, related sections and the supplier's installation manual, the warranty on the Monitoring and Control equipment must be 12 months from date of Substantial Completion.

4.24.7. **Products**.

4.24.7.1. **Monitoring and Status.**

- The pump manufacturer must supply a Control system designed to monitor and control his pumps. The Monitoring system must be mounted in the cabinet and contain per pump 1 Base unit acting as a gateway between the Pump and the Central Monitoring and a Central Control Unit (CU). The CU must be able to control up to 10 Pumps.
- Each pump must be connected by just 2 controls leads to the base unit (BU). The control leads must be part of the Motor cable. An additional Pilot cable must not be allowed.
- The Base Unit (BU) must be able to stop the pump if required via an interlocking relay and it must provide connections for optional measuring modules such as a power meter and other I/O modules.
- The central unit (CU) must be provided for external access and information exchange with the monitoring system via one single point. The user should be able to connect to the CU via an RJ45 jack to Local PC point to point and Local area network.
- A local operator panel must be possible to connect to the CU via a separate RJ45 socket.
- The CU must have a functionality based on embedded web pages that can be used through a PC or operator panel that allows:
  - A graphical user interface for configuration and analysis via computer and HMI
  - Pump status overview
  - Alarm management
  - Analysis through trend graphs and histograms.
  - External communication with any SCADA via Modbus RTU or Modbus TCP
- The CU must contain the same pump data and logged data stored in each pump electronic module for quick access and redundancy.
- The system must support the service and maintenance policy that applies to the pump by generating service reminders and graphically providing users with an overview of service status that facilitates planning of upcoming service
- The Cabinet must be equipped with HMI Touch panel for access and interaction with the Monitoring and Control system. The panel should be at least 15 in. in size and able to show color.
- When a pump related alarm is generated, the system must support the user in the form of:
  - Measurement data linked to the specific alarm item for analysis.
  - Text information about possible root cause errors.
  - Remedial actions.

4.24.7.2. **Soft starter. (DANFOSS MCD 600, Square D, or Approved Equal)**.

- The soft starter must be provided by the manufacturer in configuration suitable for panel mounting or wall mounting. Power devices and components must be inaccessible during routine maintenance or set-up.
- The manufacturer must be able to provide the soft starter in a packaged NEMA 12 enclosure with fused disconnect, motor overload, remote keypad, and control power transformer.
- The soft starter must use a three-phase thyristor (SCR) bridge consisting of at least two SCR's per phase to control the starting and stopping of standard motors.

- The soft starter must incorporate a “self-cleaning” function to remove debris from the impeller. The cleaning function must consist of forced stopping, reversal and forward runs timed to allow for debris to fall from the impeller. After cleaning cycle is complete, drive must resume to automatic operation.
- The soft starter must provide current-feedback (closed-loop) control for linear acceleration without external feedback independent of motor load or type of application. The gating of the thyristors will be controlled in such a manner to ensure a smooth and stable acceleration ramp.
- The soft starter must operate by modulating the output voltage to maintain a user defined start current. Voltage ramp (“open loop”) and current limiting (voltage clamping) type soft starts are not acceptable.
- The soft starter must use Adaptive Acceleration Control which allows selection of different acceleration and deceleration profiles unique to application needs and be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCR’s.
- The soft starter must be designed to operate in an ambient temperature from 0 to 104°F and applicable for following site conditions:
  - Storage temperature form -10 to 140°F.
  - Relative humidity up to 95% at 104°F.
  - Designed to operate in altitudes up to 3300 ft
  - Capable to operate without limitation between +10% and –15% of nominal voltage.
- The soft starter must automatically adapt for operation at 50 to 60 Hz. Frequency tolerance must be +2% to –5% when starting and between +2% to –5% during steady state operation. A microprocessor controlled thermal protection system must be included which continuously calculates the temperature rise of the motor and soft start. It must also provide phase loss, phase reversal, under load, stall, and jam protection.
- The soft starter must be capable of supplying 350% of rated full load current for 30 seconds 10 times per hour at maximum ambient temperature. The manufacturer must supply rating information and PC-based selection tools to determine the appropriate rating of the starter for the specific application. The contractor must supply the appropriate data from the motor and driven load to the soft starter manufacturer.
- Dialog functions, display units, remote functions, terminal blocks, configuration switches must be accessible on the front of the control module. Exposure to control circuits during routine adjustments is prohibited.
- Digital indication must provide, as a minimum, the following conditions:
  - Soft start status – ready, starting, stopping, run.
- Motor status – Current, Thermal status. Fault status – Shorted SCR trip, Excess start time trip, Overcurrent trip, Motor thermistor trip, Phase imbalance trip, Supply frequency trip, Phase rotation trip, Instantaneous overload trip, Power circuit fault, Undercurrent trip, RS485 communications fault, EEPROM read/write failure. A Graphical LCD user interface must be used to configure the following operating parameters as required:
  - Motor full load amps adjustable from 50 to 130% of the controller rating.
  - Current limitation on starting adjustable from 10 to 550% of motor full load rating.
  - Total start time adjustable from 1 to 255 seconds.
  - Current limit adjustable from 10 to 550% of nominal motor current.
  - Selectable Torque boost.
  - Selection of freewheeling or coasting, soft stop, or DC braking.
  - Adjustable soft stop current ramp time from 1 to 100 seconds.
  - Braking torque level adjustable from 30% to 100% effectiveness.
  - Selection of Overload Class (2, 10, 10A, 15, 20, 25, or 30) must be integral to built-in motor thermal overload protection.
  - Selectable automatic reset operation.
  - Assignment of controller’s inputs and outputs.

- Activation of phase reversal protection.
- Reset of motor thermal state.
- Return to factory default settings.
- Three output relays configurable for, line contactor, Run, Tripped, High current flag, low current flag, Output on, DC brake contactor.

4.24.7.3. **Pump Station Controller**. The pump station controller must provide automatic control of the pumps with an HMI display interface.

- The minimum features available in the pump controller must include:
  - Pump control of up to 6 pumps; including pump grouping and pump alternation.
  - Intelligent Hand-Off-Auto Control for each pump from the main display keypad as follows:
  - Hand mode (semi-automatic, non-maintained manual mode), the pump switches off at the deactivation set point and then resets to Auto mode for the next pump run cycle.
  - Hand mode (fully manual, maintained mode). To pump beyond the off (deactivation) set point, the Hand-Off-Auto button must be held down by the user for failsafe control.
- Level set point adjustment for pump activation, deactivation, and station level alarms.
- Level device inputs must include: 4-20mA analog signals, conductive probes, or floats.
- Redundant level device inputs with automatic fault control (input device switching).
- Selectable charge (fill) or discharge (empty) modes.
- Pre-configured station optimization features must include:
  - Maximum pumps to run
  - Maximum starts per hour
  - Maximum pump run time
  - Pump maintenance run function
- Pump alternation modes must include:
  - Standard alternation of pumps
  - Fixed sequence pump control
  - User defined alternation using a (N:1) or (N:M) ratio
  - Alternation based on the most efficient pump
  - Alternation by the number of hours run
  - Alternation by the number of starts within a specified time period
- Pump decommissioning mode to allow one or more pumps to be fully decommissioned.
- Up to 6 unique user defined profiles of set points must be available to control pumps during specific site conditions or events. Features must include:
  - Automatic profile change based on date and time
  - Profile selection option from SCADA (remote control), digital input, logic tag or local keypad
- Locked level alarm function to indicate a level device fault.
- Analog input signal watcher function to monitor analog input values for control and alarm uses.
- Level simulation function for pump station commissioning and general testing.
- A datalogger for user-defined faults and events must include:
  - Recording of up to 50,000 events to internal flash memory
  - Download capability up to 10,000,000 events in the form of a comma delimited (csv) file
- Three phase supply voltage monitoring and supply fault management for the following conditions:
  - Under-voltage, Over-voltage
  - Phase fail, Phase rotation
- Monitoring of DC power supply, battery voltage, and internal controller temperature.
- Energy, power, and pump efficiency monitoring:
  - kW, kVA, power factor, kWHr, KVAH calculation for each pump
  - Pump efficiency calculation (gallons per KWHr) for each pump

- Power supply data (voltage, frequency, and phase angle information)

- Motor fault protection features:
  - 3-phase current monitoring for each pump
  - Over current fault detection
  - Under current fault detection
  - Ground fault detection
  - Current phase imbalance fault
  - Motor insulation resistance failure detection
- Flow measurement: (when enabled by software key)
  - Calculated flow by liquid level draw down method
  - Flow monitoring by inputs from a flow meter (analog input and pulsed signal input)
  - Flow alarms for pumps and total station flow
- VFD speed control function (when enabled by software key)
- Fault handling functions:
  - Pump hold out function
  - Automatic reset function after fault condition is no longer present
  - Manual reset of fault (if user intervention of fault reset is required)
- Remote control functions via remote telemetry: (when enabled with software key)
  - Change the operating mode of pumps (hand/off/auto operations)
  - Reset of pump faults and station faults
  - Change pump and alarm set point values
  - Change the operational profile of the pumps
- Security
  - User defined password management for access to programming areas in the controller
  - Automatic data logging of personnel who have entered the programming areas
  - Automatic logging of unsuccessful login attempts with a date and time stamp
  - Digital input option for controlled access to programming areas
- SD and USB media access ports must be available for the following operations:
  - Firmware upgrades
  - Saving or loading pump controller configuration information
  - Exporting or importing MODBUS and DNP3 points list information
  - Downloading data logs
- Advanced programming functions: (when enabled by software key)
  - The pump controller must have the ability to be used with IEC61131-3 and IEC61499 compliant PLC programming languages to enhance or modify existing functionality.
  - Isa Graf software programming and Logic Engine scripting language must be supported.
- The pump controller must include a separate user interface (HMI display) keypad for configuration settings, control operations, and advanced programming. The following parameters must be displayed on the main screen:
  - Liquid level in percent, meters, feet, inches, or other custom defined units
  - Set points for pump control and level alarms
  - Pump status (running, stopped or next to run)
  - Pump availability indication
  - Pump fault indication
  - Three user configurable lines of information to display pump station status and data
- The main screen must include an INFO button to view the following pump station information:
  - Hours Run counter for each pump and the pump station to include:
    - minutes run for last pump cycle
    - total minutes (hourly)

- total hours today, total hours yesterday
- total hours this week, total hours last week
- total accumulated hours

- Pump Start counter for each pump and the pump station including:
  - pump starts this hour, pump starts last hour
  - pump starts today, pump starts yesterday
  - pump starts this week, pump starts last week
  - total accumulated pump starts
- Flow values (when enabled by software key)
  - station inflow rate
  - pump flow rate
  - total station volume
  - overflow data (including overflow start time, duration, estimated volume)
- Power and Efficiency
  - pump efficiency in gallons or liters per KWHr – or KVAh
  - power in kW, KVA
  - power factor
  - energy accumulators per pump in KWHr and KVAH
- Insulation resistance value for each pump motor in Ohms
- I/O Status
  - Digital I/O status and accumulated values
  - Analog I/O status with a value in mA and a scaled value
  - 3-phase voltage, frequency, phase angle, power factor
- Database viewer function to review statistics and tag data information in real time.
- Communications information and statistics.

■ The main screen must include a FAULT button to view fault information as follows:
- The fault screen will provide fault details along with a date/time stamp.
- A fault reset option must be presented to the user.

■ The main screen must include a HISTORY button to browse history information as follows:
- View recorded pump station events along with a date/time stamp
- The history log must be capable of being filtered to display individual events

■ The main screen must include a SETTINGS button to configure the pump controller as follows.
- Set point programming of pump activation values and level alarm values
- Enable/Disable level alarms, faults and historical data recording
- Configuration of Inputs and Outputs
- Setup parameters for each type of fault available in the pump controller
- Set alternation mode for pumps
- Configure station optimization parameters
- Configure voltage supply monitoring parameters
- Configure motor monitoring parameters
- Configure communications parameters
- Configure data logging parameters
- Enable level simulation session
- Create or restore backup copies of the pump controller configuration settings
- Restart the pump controller

■ The Hardware must have following features.
- The pump controller inputs and outputs must be modular and must be expandable.
- Available I/O types must include:

- Digital Inputs (discrete, voltage free input)
- Digital Outputs (dry contact type, rated at 240VAC/DC, 5A resistive)
- Analog Inputs (10bit)
- Analog Outputs (10bit)

▪ Digital Inputs must be configurable based on specific input requirements as follows:
- Pump sensor inputs: Flygt FLS circuit, Conductive Seal, PTC Thermistor (_vertempt)
- Conductive probe sensing (for liquid level monitoring)
- 2 High speed counter inputs

▪ The pump controller must include the following data communication ports:
- 2 Ethernet ports (10Mbit/s)
- 2 RS232 ports (115kBit/s)
- 2 RS485 ports (115kBit/s)
- 1 USB device port
- 1 SD card port

■ The pump controller must support the following communication types.
▪ TCP/IP Ethernet
▪ UDP
▪ RS232 Serial Data
▪ RS485 Serial Data
▪ Private radio over RS232
▪ PSTN (Dial-up)
▪ Wireless LAN
▪ Cellular Communications

■ It must be able to communicate with following protocols.
▪ DNP3 (master & slave, level 2 compliant)
▪ Modbus (master & slave) as follows: Modbus TCP, Modbus RTU, Modbus ASCII

■ The pump station controller must be designed for following environment and performance.
▪ Central Processing Unit Speed: 566MHz
▪ Central Processing Unit RAM Size: 256Mbyte
▪ Central Processing Unit Flash Memory Size: 64Mbyte
▪ Real Time Clock (with battery backup)
▪ Working temperature: -10°C to +60°C
▪ Storage temperature: -40°C to +90°C
▪ Humidity: 5% to 95% (non-condensing)
▪ IP Ratings: Controller Base Unit (IP20, NEMA 1), Display Keypad (IP65, NEMA4)

4.24.7.4. **Backup control system (Multitrode, Goulds, or Approved Equal)**.

■ The backup control equipment must be supplied with the following specifications.
▪ The control relay must accept 2 or 3 level inputs from ball floats
▪ The following settings must be dip switch programmable from the front panel:
- Conductive probe sensitivity adjustment.
- Activation Delays.
- Charge/Discharge selection. (MTR Relay)
- Level Alarm Output (MTRA and SAFE-TL Relay)
- Overtemp and Seal Condition Detection (SAFE-TL Relay)

▪ Mounting and Installation: DIN Rail or 2 x #6 screws Base Mount

■ Output Contact Rating: 250VAC, 5 Amps Resistive, 2 Amps Inductive.

4.24.7.5. **Hazardous Location Protective Device**. (Flygt, Allen Bradley, or Approved Equal). The Hazardous Area Protective Device is intended to protect equipment and personnel in areas where hazardous conditions may be present.

The intrinsically safe device must be supplied according to the following specifications.

- The intrinsically safe barrier must be panel mounted and designed to protect a multi-sensor conductive probe or ball float inputs.
- The barrier must be certified intrinsically safe for use with equipment in installations up to and including Class 1 Zone O.
- The intrinsically safe barrier must have screw terminals for wire connections.
- The intrinsically safe barrier must be protected and current limited according to the requirements of UL Class I (Groups A, B, C & D), Class II (Groups E, F, & G) and Class III certification.
- The device must also be CE and CSA listed for applicable locations and must allow a maximum short circuit current of 10 ma.
- The intrinsically safe barrier must be surface mounted using the mounting flanges on either side of the unit assembly.
- The unit must be fastened with approved screws or bolts in conformance with UL requirements.

4.24.7.6. **Control Panel Construction and Assembly**.

- General Requirements:
  - Install the control panel on a level which can't be flooded even by storm water.
  - Install the controller in the Pump Station Controller.
  - The control Panel must be manufactured in accordance with ISO 9000-2001 specifications and must be so constructed for the application of a UL Listing Label by an approved UL Control Panel Assembly Facility.
  - Properly inspect electrical connections and torque in compliance with ISO specifications. Make external connections to the control panel by way of numbered terminal blocks.
  - Control Panels must be properly checked and load tested with power applied. A control panel test log must be supplied with the control panel.
  - Control Panels must be supplied from a UL approved control panel assembly facility with of the required labels properly attached.
- Control Panel Enclosure Environmental Rating. Control Panel Enclosure rating must be specified in accordance with the project requirements or the contract drawings as either NEMA 12,
- Control Panel Enclosure Requirements.
  - Enclosure must be sized according to physical and functional device requirements.
  - Enclosure seams must be continuously welded and ground smooth.
  - Enclosure door opening flange trough must exclude liquids and contaminants.
  - Enclosure must include an integral body grounding stud and sub-panel mounting studs and be wall mounted, unless otherwise specified.
  - Enclosure door must have hidden hinges for a clean, aesthetic appearance.
  - Enclosure door opening angle must be standard, full access, 135-degree opening radius.
  - Enclosure door must be interchangeable and removable by pulling a hinge pin.
  - Enclosure door must have a high-impact thermoplastic data pocket mounted on the inner side of the enclosure door and must have a seamless, foam-in-place, one-piece gasket to provide an oil-tight, dust-tight seal against contaminants.
  - Enclosure must have a three-point latching system with a zinc die-cast handle that is painted with black textured polyester powder paint.
  - Enclosure handles must be capable of being padlocked.
  - Steel sub-panel must be white.

- When enclosure cut-outs for instruments and other devices are required, holes must be cut, punched, or drilled and finished with rounded edges.

- Instrument Location Requirements.
  - Instruments or control devices designated for sub-panel (back) mounting must be located in a manner that will allow for maintenance and adjustment.
  - Instrument mounting height must not exceed 6'-6" to the top of the instrument and must not be lower than 3'-0" to the bottom of the instrument (unless otherwise specified).
- Wiring Requirements.
  - Wiring for AC and DC control circuits must be Type SIS or Type MTW stranded copper and must be sized for the applied voltage and current. Unless otherwise noted, control circuit wiring must not be smaller than No. 16 AWG.
  - Cable wiring for analog signal circuits must be twisted, shielded pairs of stranded copper conductors that must not be smaller than No. 20 AWG.
  - Wiring for special signaling equipment such as communications, digital data, and multiplexed signals must be provided by the equipment supplier.
  - Wiring must be numbered and marked at each termination point.
  - Terminal blocks for internal or external wiring must be DIN rail mounted with screw compression type terminals and machine printed labels.
- Nameplate Requirements.
  - Nameplates are defined as inscribed, plastic plates mounted above or near a panel face mounted component. Unless otherwise noted, nameplates must be engraved, rigid, laminated plastic with an adhesive back. Nameplate color must be blue with white letters.
  - Component Labels are defined as printed, vinyl labels mounted above, below or near a sub-panel (back) mounted component for identification. Printed vinyl labels must be white in color with black letters and an adhesive back.
- Grounding.
  - Control Panel enclosure must be properly grounded in conformance with the National Electrical Code and local code requirements.
  - Each analog signal loop must have a shield wire connected to ground at a single point for the loop. Shields must be grounded at control panels where signals are input to the receiving device and not at the source of the transmitting device.
- Electrical Transient (Surge) Protection.
  - All electrical and electronic components of the Control Panel must be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and surges in nearby electrical systems.
  - The transient surge protector must be rated for 25kA per phase or larger.
- Circuit Breakers.
  - Power Circuit Breakers must be thermal magnetic type designed for AC current with a minimum interrupting capacity of 15,000 amperes.
  - Control Circuit Breakers must be in accordance with section UL 489 with a minimum interrupting capacity of 10,000 amperes.
- Control Power Transformers. Control Power Transformers required to provide control system and accessory power must be machine tool type control transformers with epoxy encapsulated coils or resin impregnated coils, high quality silicon steel laminations, copper magnet wire, molded terminals and 55° C rise (Class 10 insulation system).
- Supply Voltage/Phase Monitor.
  - The voltage-phase monitor must continually measure the voltage of each of the three phases of the incoming power to the equipment and provide protection for three phase motors and sensitive electronics.

- The phase monitor must sense the following conditions: under- and over-voltage, voltage unbalance, phase loss and phase reversal.

- Control Relays.
  - Control relays must be square base type with coil voltage (120VAC, 12VDC or 24VDC).
  - Control relays must be 4PDT (4 Pole, Double Throw) with normally closed or normally open contacts rated at 120VAC, 5 amp minimum.
  - Control relays must include an integrated test button and relay energized flag indicator.
- Full Voltage Magnetic Motor Controller.
  - The motor controller must be a NEMA rated, full voltage, non-reversing, across the line contactor and overload relay combination.
  - The motor overload relay must be an ambient compensated type with inverse-time-current characteristic and must be provided with heaters or sensors in each phase matched to nameplate full load current of the specific motor to which it connects.
- GFCI Convenience Receptacle. There must be a 120VAC, 15 Amp GFCI rated convenience receptacle mounted on the dead front swing door of the control panel. Receptacle circuit must be protected by a thermal magnetic circuit breaker.
- Enclosure Condensation Heater.
  - There must be a 120VAC, 50-watt enclosure heater inside the control panel.
  - The heater must be a silicone rubber, insulated strip type enclosure heater.
  - The heater must be Chromalox Model #SL-B-2-5-55P, or approved equal.
- Local Alarm (Flashing Light). Install a Flashing Alarm Light mounted on top of the control panel enclosure for local alarm indication. Supply the flashing alarm light according to the following specifications:
  - UL Recognized for use with UL NEMA Type 12 Enclosures.
  - Shatter Resistant Lexan globe, U.V. Stabilized and Flame Retardant.

The Flashing Alarm Light must be by Ingram Products, equivalent by Phoenix Contacts or approved equal.

4.24.8. **Execution**. Perform installation in conformance with this Item and manufacturers specifications.

4.24.8.1. **Examination**. A factory trained technician must examine the work area before beginning work and check the following:

- The environment is safe to work in.
- Surfaces are ready to receive work.
- Tools are in the proper location and are in good condition.
- The system is grounded.

4.24.8.2. **Field Quality Control**. The follow field tests must be performed by a factory trained technician.

- Point to point wiring verification
- Utility power verification
- Site acceptance testing
- System demonstration

Point to Point I/O Verification. After installation of the pumps and the control panel, a factory trained technician must prepare the I/O checklist. The checklist must include the following:

- Inputs and outputs connected to the control panel.
- Alarms that can be generated by the control panel.

The technician must follow a test procedure to test I/O and alarms.

- Test digital inputs from point of origin unless it is unsafe.

- Test digital outputs by running a simulation test from the controller or by simulating the fault condition.
- Test analog inputs from the point of origin where possible and by use of a signal generator otherwise.
- Test analog outputs by running a simulation program or by forcing the output to a value.

The technician must follow a test procedure to ensure the system operation parameters are met.

Configuration Verification. The factory trained technician must document the settings using a factory provided configuration checklist. Each parameter must be verified before the beginning of testing and then again after testing is completed. The configuration of the pump station manager as well as the IPS gateways must be documented. The pump station manager configuration must be saved to a factory provided SD card after testing is completed.

4.24.8.3. **Factory Trained Supervision**. Procure a factory trained technician to check over equipment before putting the equipment into operation. Perform point-to-point testing of the wiring. Perform functional test of the equipment alarms and controls.

4.24.8.4. **Certification of Testing**. Tests must be performed in the presence of a duly authorized representative of the Engineer. If the presence is waived, provide certified results. Written notice of tests must be given two weeks in advance.

4.24.8.5. **Test Equipment**. Test equipment must be provided by the Contractor.

4.24.8.6. **Training**. Training must be a minimum of 4 hr. and cover the complete Pumping System and related controls. Instruction material must be provided for at least 4 trainees.

4.25. **I/O List**. (Refer to Table Below)

Table 2
I/O Values

Equipment	Description	Type	Low Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #1	In-Hand	DI	Pump Not in Hand	Pump In Hand	Primary Modbus Communication
Storm Water Pump #1	Pump Speed Command	AO	4 mA	20 mA	Primary Modbus Communication
Storm Water Pump #1	Pump Speed Indication	AI	4 mA	20 mA	Primary Modbus Communication
Storm Water Pump #1	Pump Running	DI	Pump Stopped	Pump Running	Primary Modbus Communication
Storm Water Pump #1	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water Pump #1	Seal Fail	DI	N/A	Pump Seal Fail	Primary Modbus Communication
Storm Water Pump #1	VFD Mode	DI	VFD -Bypass	VFD-Fault	Primary Modbus Communication
Storm Water Pump #1	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Primary Modbus Communication
Storm Water Pump #1	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication

Storm Water Pump #1	VFD High Temp	DI	N/A	VFD High Temp	Primary Modbus Communication
Storm Water Pump #1	SSRV Fault	DI	N/A	SSRV Fault	Primary Modbus Communication
Storm Water Pump #1	SSRV Overload	DI	N/A	SSRV Overload	Primary Modbus Communication
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Storm Water Pump #1	Primary Communication Fail	DI	N/A	Communicatio n Fail	Primary Modbus Communication
Storm Water Pump #1	SWP #1 Deviation Alarm	DI	N/A	Deviation Alarm	Primary Modbus Communication
Storm Water Pump #1	SWP #1 E-Stop	DI	N/A	E-Stop	Hardwire
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Redundant Hardwire
Storm Water Pump #1	In-Hand	DI	Pump Not in Hand	Pump In Hand	Redundant Hardwire
Storm Water Pump #1	Pump Running	DI	Pump Stopped	Pump Running	Redundant Hardwire
Storm Water Pump #1	High Temp	DI	N/A	Motor High Temperature	Redundant Hardwire
Storm Water Pump #1	Seal Fail	DI	N/A	Pump Seal Fail	Redundant Hardwire
Storm Water Pump #1	VFD Mode	DI	VFD -Bypass	VFD-Fault	Redundant Hardwire
Storm Water Pump #1	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Redundant Hardwire
Storm Water Pump #1	VFD Fault	DI	N/A	VFD Fault	Redundant Hardwire
Storm Water Pump #1	VFD High Temp	DI	N/A	VFD High Temp	Redundant Hardwire
Storm Water Pump #1	SSRV Fault	DI	N/A	SSRV Fault	Redundant Hardwire
Storm Water Pump #1	SSRV Overload	DI	N/A	SSRV Overload	Redundant Hardwire
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Redundant Hardwire
Storm Water Pump #1	SW #1 Pump Deviation Alarm	DI	N/A	Deviation Alarm	Redundant Hardwire
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #2	In-Hand	DI	Pump Not in Hand	Pump In Hand	Primary Modbus Communication
Storm Water Pump #2	Pump Speed Command	AO	4 mA	20 mA	Primary Modbus Communication
Storm Water Pump #2	Pump Speed Indication	AI	4 mA	20 mA	Primary Modbus Communication
Storm Water Pump #2	Pump Running	DI	Pump Stopped	Pump Running	Primary Modbus Communication
Storm Water Pump #2	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water	Seal Fail	DI	N/A	Pump Seal Fail	Primary Modbus

Pump #2					Communication
Storm Water Pump #2	VFD Mode	DI	VFD -Bypass	VFD-Fault	Primary Modbus Communication
Storm Water Pump #2	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Primary Modbus Communication
Storm Water Pump #2	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Storm Water Pump #2	VFD High Temp	DI	N/A	VFD High Temp	Primary Modbus Communication
Storm Water Pump #2	SSRV Fault	DI	N/A	SSRV Fault	Primary Modbus Communication
Storm Water Pump #2	SSRV Overload	DI	N/A	SSRV Overload	Primary Modbus Communication
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Storm Water Pump #2	Primary Communication Fail	DI	N/A	Communicatio n Fail	Primary Modbus Communication
Storm Water Pump #2	SWP #2 Deviation Alarm	DI	N/A	Deviation Alarm	Primary Modbus Communication
Storm Water Pump #2	SWP #2 E-Stop	DI	N/A	E-Stop	Hardwire
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Redundant Hardwire
Storm Water Pump #2	In-Hand	DI	Pump Not in Hand	Pump In Hand	Redundant Hardwire
Storm Water Pump #2	Pump Running	DI	Pump Stopped	Pump Running	Redundant Hardwire
Storm Water Pump #2	High Temp	DI	N/A	Motor High Temperature	Redundant Hardwire
Storm Water Pump #2	Seal Fail	DI	N/A	Pump Seal Fail	Redundant Hardwire
Storm Water Pump #2	VFD Mode	DI	VFD -Bypass	VFD-Fault	Redundant Hardwire
Storm Water Pump #2	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Redundant Hardwire
Storm Water Pump #2	VFD Fault	DI	N/A	VFD Fault	Redundant Hardwire
Storm Water Pump #2	VFD High Temp	DI	N/A	VFD High Temp	Redundant Hardwire
Storm Water Pump #2	SSRV Fault	DI	N/A	SSRV Fault	Redundant Hardwire
Storm Water Pump #2	SSRV Overload	DI	N/A	SSRV Overload	Redundant Hardwire
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Redundant Hardwire
Storm Water Pump #2	SW #2 Pump Deviation Alarm	DI	N/A	Deviation Alarm	Redundant Hardwire
Storm Water Pump #3	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #3	In-Hand	DI	Pump Not in Hand	Pump In Hand	Primary Modbus Communication
Storm Water Pump #3	Pump Speed Command	AO	4 mA	20 mA	Primary Modbus Communication

Storm Water Pump #3	Pump Speed Indication	AI	4 mA	20 mA	Primary Modbus Communication
Storm Water Pump #3	Pump Running	DI	Pump Stopped	Pump Running	Primary Modbus Communication
Storm Water Pump #3	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water Pump #3	Seal Fail	DI	N/A	Pump Seal Fail	Primary Modbus Communication
Storm Water Pump #3	VFD Mode	DI	VFD -Bypass	VFD-Fault	Primary Modbus Communication
Storm Water Pump #3	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Primary Modbus Communication
Storm Water Pump #3	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Storm Water Pump #3	VFD High Temp	DI	N/A	VFD High Temp	Primary Modbus Communication
Storm Water Pump #3	SSRV Fault	DI	N/A	SSRV Fault	Primary Modbus Communication
Storm Water Pump #3	SSRV Overload	DI	N/A	SSRV Overload	Primary Modbus Communication
Storm Water Pump #3	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Storm Water Pump #3	Primary Communication Fail	DI	N/A	Communicatio n Fail	Primary Modbus Communication
Storm Water Pump #3	SWP #3 Deviation Alarm	DI	N/A	Deviation Alarm	Primary Modbus Communication
Storm Water Pump #3	SWP #3 E-Stop	DI	N/A	E-Stop	Hardwire
Storm Water Pump #3	In-Auto	DI	Pump Not in Auto	Pump In Auto	Redundant Hardwire
Storm Water Pump #3	In-Hand	DI	Pump Not in Hand	Pump In Hand	Redundant Hardwire
Storm Water Pump #3	Pump Running	DI	Pump Stopped	Pump Running	Redundant Hardwire
Storm Water Pump #3	High Temp	DI	N/A	Motor High Temperature	Redundant Hardwire
Storm Water Pump #3	Seal Fail	DI	N/A	Pump Seal Fail	Redundant Hardwire
Storm Water Pump #3	VFD Mode	DI	VFD -Bypass	VFD-Fault	Redundant Hardwire
Storm Water Pump #3	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Redundant Hardwire
Storm Water Pump #3	VFD Fault	DI	N/A	VFD Fault	Redundant Hardwire
Storm Water Pump #3	VFD High Temp	DI	N/A	VFD High Temp	Redundant Hardwire
Storm Water Pump #3	SSRV Fault	DI	N/A	SSRV Fault	Redundant Hardwire
Storm Water Pump #3	SSRV Overload	DI	N/A	SSRV Overload	Redundant Hardwire
Storm Water Pump #3	Pump Fail	DI	N/A	Pump Fail	Redundant Hardwire
Storm Water Pump #3	SW #3 Pump Deviation Alarm	DI	N/A	Deviation Alarm	Redundant Hardwire

Storm Water Pump #4	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #4	In-Hand	DI	Pump Not in Hand	Pump In Hand	Primary Modbus Communication
Storm Water Pump #4	Pump Speed Command	AO	4 mA	20 mA	Primary Modbus Communication
Storm Water Pump #4	Pump Speed Indication	AI	4 mA	20 mA	Primary Modbus Communication
Storm Water Pump #4	Pump Running	DI	Pump Stopped	Pump Running	Primary Modbus Communication
Storm Water Pump #4	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water Pump #4	Seal Fail	DI	N/A	Pump Seal Fail	Primary Modbus Communication
Storm Water Pump #4	VFD Mode	DI	VFD -Bypass	VFD-Fault	Primary Modbus Communication
Storm Water Pump #4	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Primary Modbus Communication
Storm Water Pump #4	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Storm Water Pump #4	VFD High Temp	DI	N/A	VFD High Temp	Primary Modbus Communication
Storm Water Pump #4	SSRV Fault	DI	N/A	SSRV Fault	Primary Modbus Communication
Storm Water Pump #4	SSRV Overload	DI	N/A	SSRV Overload	Primary Modbus Communication
Storm Water Pump #4	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Storm Water Pump #4	Primary Communication Fail	DI	N/A	Communicatio n Fail	Primary Modbus Communication
Storm Water Pump #4	SWP #4 Deviation Alarm	DI	N/A	Deviation Alarm	Primary Modbus Communication
Storm Water Pump #4	SWP #4 E-Stop	DI	N/A	E-Stop	Hardwire
Storm Water Pump #4	In-Auto	DI	Pump Not in Auto	Pump In Auto	Redundant Hardwire
Storm Water Pump #4	In-Hand	DI	Pump Not in Hand	Pump In Hand	Redundant Hardwire
Storm Water Pump #4	Pump Running	DI	Pump Stopped	Pump Running	Redundant Hardwire
Storm Water Pump #4	High Temp	DI	N/A	Motor High Temperature	Redundant Hardwire
Storm Water Pump #4	Seal Fail	DI	N/A	Pump Seal Fail	Redundant Hardwire
Storm Water Pump #4	VFD Mode	DI	VFD -Bypass	VFD-Fault	Redundant Hardwire
Storm Water Pump #4	VFD Local-Remote	DI	VFD -Local	VFD-Remote	Redundant Hardwire
Storm Water Pump #4	VFD Fault	DI	N/A	VFD Fault	Redundant Hardwire
Storm Water Pump #4	VFD High Temp	DI	N/A	VFD High Temp	Redundant Hardwire
Storm Water	SSRV Fault	DI	N/A	SSRV Fault	Redundant

Pump #4					Hardwire
Storm Water Pump #4	SSRV Overload	DI	N/A	SSRV Overload	Redundant Hardwire
Storm Water Pump #4	Pump Fail	DI	N/A	Pump Fail	Redundant Hardwire
Storm Water Pump #4	SW #4 Pump Deviation Alarm	DI	N/A	Deviation Alarm	Redundant Hardwire
Sludge Pump	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Sludge Pump	In-Hand	DI	Pump Not in Hand	Pump In Hand	Primary Modbus Communication
Sludge Pump	Running – Reverse	DI	N/A	Pump Running – Reverse	Primary Modbus Communication
Sludge Pump	Running – Forward	DI	N/A	Pump Running – Forward	Primary Modbus Communication
Sludge Pump	Pump Speed Indication	AI	4 mA	20 mA	Primary Modbus Communication
Sludge Pump	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Sludge Pump	Seal Fail	DI	N/A	Pump Seal Fail	Primary Modbus Communication
Sludge Pump	Pump Clog	DI	N/A	Pump Clogged	Primary Modbus Communication
Sludge Pump	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Sludge Pump	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Sludge Pump	Primary Communication Fail	DI	N/A	Communicatio n Fail	Primary Modbus Communication
Sludge Pump	Backup Float Control Active	DI	N/A	Backup Float Active	Hardwire Communication
Sludge Pump	Sludge Pump Deviation Alarm	DI	N/A	Deviation Alarm	Primary Modbus Communication
Sludge Pump	E-Stop	DI	N/A	E-Stop	Hardwire Communication
Station	Backup Float Control Active	DI	N/A	Backup Float Active	Hardwire Communication
Concertor – Float	Backup Float – Stop	DI	N/A	Pump Start – Back-up	Hardwire Communication
Concertor – Float	Backup Float – Start	DI	N/A	Pump Stop – Back-up	Hardwire Communication
SWPs – Float	Wet Well High – Level	DI	N/A	Wet Well High	Hardwire Communication
SWPs – Float	Lead Stop	DI	N/A	Pump Stop	Hardwire Communication
SWPs – Float	Lead Start	DI	N/A	Pump Start	Hardwire Communication
SWPs – Float	Lag 1 Stop	DI	N/A	Pump Stop	Hardwire Communication
SWPs – Float	Lag 1 Start	DI	N/A	Pump Start	Hardwire Communication

SWPs – Float	Lag 2 Stop	DI	N/A	Pump Stop	Hardwire Communication
SWPs – Float	Lag 2 Start	DI	N/A	Pump Start	Hardwire Communication
SWPs – Float	Lag 3 Stop	DI	N/A	Pump Stop	Hardwire Communication
SWPs – Float	Lag 3 Start	DI	N/A	Pump Start	Hardwire Communication
Transducer	Continuous Wet Well Level	AI	4 mA	20 mA	Hardwire Communication
Transducer	Transducer Fail	DI	N/A	Transducer Fail	Hardwire Communication
Generator	Generator Fault	DI	N/A	Generator Fail	Hardwire Communication
Generator	Generator Running	DI	N/A	Generator Running	Hardwire Communication
Generator	Generator Low Fuel	DI	N/A	Generator Low Fuel	Hardwire Communication
ATS	Position	DI	Utility Power	Utility Power Fail	Hardwire Communication
ATS	ATS Fault	DI	N/A	ATS Fault	Hardwire Communication
Power Monitor (PM)	PM – Fault	DI	N/A	PM Fault	Hardwire Communication
Power Monitor (PM)	Undervoltage	DI	N/A	Undervoltage	Hardwire Communication
Power Monitor (PM)	Overvoltage	DI	N/A	Overvoltage	Hardwire Communication
TVSS	TVSS Fail	DI	N/A	TVSS Fail	Hardwire Communication
Control Power	Control Power Fail	DI	N/A	Control Power Fail	Hardwire Communication
UPS	UPS Fail	DI	N/A	UPS Fail	Hardwire Communication
PLC	Building Alarm	DO	N/A	Station Alarm	Hardwire Communication
PLC	SWP Call to Run	DO	N/A	Generator Start	Hardwire Communication
Ventilation System	In-Hand	DI	N/A	Ventilation System In-Hand	Hardwire Communication
Ventilation System	In-Auto	DI	N/A	Ventilation System In-Auto	Hardwire Communication
Ventilation System	Fail	DI	N/A	Ventilation System Fail	Hardwire Communication
Ventilation System	High Temp	DI	N/A	High Temperature	Hardwire Communication
AHU	AHU Fail	DI	N/A	AHU Fail	Hardwire Communication
Hatch #1	Hatch Intrusion	DI	N/A	Hatch #1 Open	Hardwire Communication
Hatch #2	Hatch Intrusion	DI	N/A	Hatch #2 Open	Hardwire Communication

Hatch #3	Hatch Intrusion	DI	N/A	Hatch #3 Open	Hardwire Communication
Hatch #4	Hatch Intrusion	DI	N/A	Hatch #4 Open	Hardwire Communication
Hatch #5	Hatch Intrusion	DI	N/A	Hatch #5 Open	Hardwire Communication
Entrance Door	Station Intrusion	DI	N/A	Door Open	Hardwire Communication
Fire Alarm	High-Temp	DI	N/A	Fire Alarm – High Temp	Hardwire Communication
Fire Alarm	Smoke Detection	DI	N/A	Fire Alarm – Smoke Detection	Hardwire Communication

4.26. **Systems Integrator and Pump Control Systems**.

4.26.1. **General Requirements**. Obtain the services of a subcontractor who will provide a complete integrated Pump Control Systems (PCS) including but not limited to provision and integration of a new Station Pump control Panel, Sludge Pump Control Panel, Level Control Station, Local control Panels, Signal duplicators, VFD/SSRVS, building security systems, building air conditioning/heat relief system, security systems, fire alarm system, generator, level control instruments, and existing Remote Terminal Unit (RTU) panels, generator field instrumentation and associated control panels, controls coordination at the Pumping Station and electrical subcontractor, programmable controller system hardware and software, and software programming as shown on the contract drawings and as specified in the Contract Documents.

The system integrator will provide programming and graphic displays of the new pumping station PLCs, OITs, and the HMI systems, modify the existing RTU. Changes must reflect any changes made to the control strategies and monitored signals under this contract. These modifications must incorporate new devices or equipment, in conformance with the Contract Documents; as well as the integration of new communication links between the PLCs and equipment associated with the new Motor Control Center at the Pumping Station.

SCADA communication. The Contractor must work with the System Integrator and electrical subcontractor to coordinate with TxDOT to relocate and expand the existing RTU to the proposed building. Existing Station operation status and alarms communication to SCADA must remain online for the duration of the project. Detailed outage requests must be coordinated with and submitted to the Department for approval.

This subcontractor will hereafter be referred to as the System Integrator (SI). The SI will have total responsibility for the design, programming, testing, start-up and implementation of the Pump Control Systems, and associated control, status, and alarm functions for Facility.

As referenced above, the SI is responsible for performance and coordination of the PLCs and Control Systems associated with the existing SCADA system and RTU.

Make the SI available for coordination with other equipment suppliers and the existing SCADA radio network for implementation of the required functions of the equipment in the Pump Control Systems.

The Systems Integrator will provide necessary junction boxes, panels, transformers, power supplies, relays, terminal blocks, fusing, grounding, and other components required to meet manufacturers' requirements and to produce complete and fully functioning systems.

- It is a requirement of these Specifications that the Systems Integrator be responsible for purchasing pump control equipment consisting of, but not limited to, the following: motor control center, PLC equipment including expansion and modifications of any existing PLC cabinet, SCADA equipment, computer software, and field instruments.

- Exception. Subject to the approval, the Contractor or sub-contractor other than the Systems Integrator may be permitted to furnish pump control items requiring complete system integration. The decision to deny or to permit pump control items to be furnished by parties other than the Systems Integrator will be final, and the Contractor will not be entitled to any claims based upon the decision rendered.

Complete Pump Control Systems integration remains the responsibility of the Systems Integrator regardless whether the Systems Integrator furnished the pump control equipment or another party was permitted to furnish some portion of the pump control equipment.

The Systems Integrator is responsible for fully understanding operating conditions, limitations, and criteria of existing motors to remain and new motors to be provided under this Contract regardless whether the motors are being furnished by other parties or are being furnished by the Systems Integrator. Furthermore, the Systems Integrator will be responsible for fully integrating motor operations required to provide a fully functioning Pump Control Systems. Motor operations requiring complete integration include, but are not limited to:

- Normal starting (VFD Operation, across-the-line starting, etc.),
- Emergency starting, as applicable,
- Running,
- Normal shutdown,
- Backup Control Operation,
- Communications Failure,
- Emergency shutdown, and
- Alarming and report-back.

As applicable to the Contract, the following components of the pump motors and the motor control center must be fully integrated into the design provided by the Systems Integrator.

- VFD's
- MCC's
- Reduced voltage soft starters
- Run contactors
- Bypass contactors
- Power factor correction capacitors
- PLC's
- Uninterruptable power supplies
- Surge protection devices
- Other protective devices
- Timers and relays
- Switches, push buttons, and indicating lights
- SCADA, monitoring devices, and recording devices

In addition to the main pumping units, other motor-driven devices that require complete integration to be provided by the Systems Integrator include the following.

- Air Conditioning/Heat Relief System
- Security System
- Fire Protection
- Generator System/ATS

Field equipment requiring complete integration by the Systems Integrator includes, but is not limited to: level transmitters, pressure transmitters, limit switches, flow switches, flow meters, differential pressure transmitters, solenoid valves, HVAC controls (thermostats, humidistats, etc.), control systems enclosures,

temperature switches, intrusion switches, light switches, beacons, control panels UPS's, ATS, power monitor, MCC, and battery chargers.

Certain field equipment require integration by the Systems Integrator into multiple systems. The Systems Integrator is responsible for fully integrating field equipment into appropriate systems as required by this Contract.

4.26.2. **Quality Assurance**.

- Regulations, Standards and Publications.
  - UL Underwriters' Laboratories, Inc.
  - NEC National Electrical Code
  - NEMA National Electrical Manufacturers Association
  - ANSI American National Standards Institute
  - IEEE Institute of Electrical and Electronic Engineers
  - ISA Instrument Society of America
- Quality Control.
  - Provide new components of the Pump Control Systems of the most current and proven design. Components must be suitable for the intended application and installed and wired in strict conformance with the manufacturer's requirements and this Specification. The System Supplier must provide the necessary junction boxes, panels, transformers, power supplies, relays, terminal blocks, fusing, grounding, and other components required to meet the manufacturer's requirements and produce a complete and functional system.
  - The complete system must comply with Federal, State, Municipal, or other authority's laws, rules, or regulations.
  - All MCCs and control panels, and their components and materials, must bear the label of the Underwriters' Laboratory. Provide control panels that are UL listed as a complete assembly.

4.26.3. **Submittals**. Components required to function as a unit must be submitted as a single item; separate submittals of individual components will not be accepted and will be returned to the Contractor as "Rejected" without further review.

- New items requiring complete integration which are not being furnished by the Systems Integrator, nevertheless, require review and approval from the Systems Integrator.
- In addition to bearing the appropriate General Contractor and sub- contractor submittal cover sheet, submittals for such new items must include a statement, signed and dated by the Systems Integrator, as follows:
- "Items included in this submittal are being furnished by parties other than the Systems Integrator. These items have been thoroughly reviewed by the Systems Integrator and have been determined to be in full compliance with the requirements of the Contract. Furthermore, the Systems Integrator has determined the items included in this submittal are fully compatible with other items requiring systems integration including both existing-to-remain items and new items to be provided under this Contract."
- Shop Drawings.
  - Submit required number of detailed shop drawings for equipment being provided for the Pump Control Systems. Shop drawings must be submitted within 90 days of the date of Notice to Proceed, but only after the required pre-submittal workshop has been conducted.
  - Shop drawings must be submitted in 3-ring loose-leaf binders and will be complete, neat, orderly, and indexed. Separate shop drawing submittals must be made for each major system component.
  - Refer to individual specification sections for specific shop drawing requirements.
  - The SI must submit a complete set of engineered drawings for the Local Control Panel, and Programmable Controller system hardware. These engineered drawings must be done by the

System Supplier using AUTOCAD. Provide drawings that are 11”x 17”, or 22”x34” as requested. Drawings include, but not be limited to, the following:

- Control panel elevation, details, front and back panel layout, and wiring diagrams showing terminal numbers and interconnecting wiring. The control panel layout drawings must include dimensions for the location of panel-mounted devices.
- Programmable controller system block diagram, power wiring diagrams and I/O wiring diagrams showing terminal numbers and interconnecting wiring.
- Color copies of screens developed for the Operator Interface Terminals along with a flow chart indicating how each screen is accessed.
- Calculations for the Uninterruptible Power Supply.
- Plan to integrate the new I/Os into the existing RTU and existing SCADA communication
- All drawings must be easily readable with minimum 1/8 inch text height.

- Prepare and submit comprehensive wiring diagrams for the instrumentation work performed under this section. Drawings must include the following:
  - Control wiring diagrams and ISA standard loop drawings with terminal numbers and control devices identified. Loop drawings, 1 per sheet. Provide diagrams in 8-12” x 11” or 11” x 14” size.
  - Drawings must show sizes and locations of equipment and their control locations. Include detailed dimensions of unit locations, elevations, details, door-mounted devices, and front and back panel layout. Include detailed dimensions of conduits, pull boxes, and wiring troughs.
  - Wiring diagrams must contain internal and external ladder wiring schematics with identified terminal numbers, relays, and other control devices. Control electrical diagrams must be drawn with circuitry arranged in functional sequence on ladder-type diagrams. Each horizontal line on the ladder diagram will be assigned a number must be written to the left or right of the ladder. Draw relay coils on the right side of the ladder. Show the line numbers on which the relay contacts appear be shown on the right of each coil. Designate a normally closed contact by drawing a diagonal line through the contact. Designate timed contacts by the letter “T” under the line number. Prepare instrument logic diagrams and schematics using ISA 55.1, IEEE 315 and 315A, and NEMA standard symbols and identification letters.
- Submit drawings in a timely manner to allow for engineering review and incorporation of additions or modifications.
- Provide a list of parts including numbers and quantities.
- Furnish final as-built drawings on diskettes compatible with AutoCAD formats.
- Control panels furnished by the Contractor must include panel layout drawings and associated wiring schematics as defined above.
- Integrator’s Data and Drawings. The Control Systems Integrator must submit a minimum of 7 complete sets of the following information for the Engineer’s approval:
  - Point-to-point wiring drawings
  - Process loop drawings
  - Dimensional drawings, wiring and piping drawings for field and pipeline-mounted equipment
  - Equipment specification sheets
  - For control panels: fabrication and nameplate legend drawings and internal wiring schematic drawings
  - Systems schematic drawings illustrating components being supplied complete with electrical interconnections

- Dimensional drawings, wiring and piping drawings for field and pipeline-mounted equipment
- Equipment specification sheets
- For control panels: fabrication and nameplate legend drawings and internal wiring schematic drawings
- Systems schematic drawings illustrating components being supplied complete with electrical interconnection.
- Computer input/output lists and a written description of the control strategy to be applied to the various process areas
- For process computer systems: system block diagram and control room layout drawings

▪ After approval, furnish 7 complete bound sets of the above information plus the following:

- Individual Operating and Maintenance Manuals
- Bulletins for each piece of equipment furnished
- Complete spare parts list for each piece of equipment
- Calibration sheets
- A minimum of 8 weeks before the factory testing, the Systems Integrator is required to submit color copies of proposed Human- Machine Interface (HMI) screens along with a flow chart indicating how each screen is accessed to the Engineer for approval.

■ Installation, Operation and Maintenance Manuals.

▪ Submit installation, operation, and maintenance manuals in 3-ring loose- leaf binder. Manuals must be complete, neat, orderly, and indexed. Submit information in accordance with Specification Section 3.

▪ Unless directed otherwise, include the following elements in the preliminary and final O&M manuals:

- Erection and installation sequence and instructions;
- Exploded view drawings and illustrations with sequence description for assembly and disassembly of equipment;
- Comprehensive parts and materials list for each equipment element indicating manufacturer and manufacturer's identification number; include name, address, and telephone numbers of sales and service offices nearest project site for each major equipment item;
- Schedules of recommended spare parts to be stocked, including part number, inventory quantity, and ordering information;
- Performance rating and nameplate data for each major system component;
- Procedures for starting, operating, adjusting, calibrating, testing, and shutting down system equipment;
- Emergency operating instructions and troubleshooting guide;
- Schedule of routine maintenance requirements and procedures, and preventative maintenance instructions required to insure satisfactory performance and equipment longevity;
- Maintenance instructions for extended out-of-service periods;
- Complete listing of software programming and licensing agreements;
- Complete operator's Supervisor's Manual for the Control System which includes system hardware and software and the "how to's" of the system;
- Testing reports;
- ISA specification sheets filled out to reflect final field instrument calibration, purchased model number, and any other as-built condition;

- As-built shop drawings of panels, wiring, instruments, etc.; and
- All standard O&M manuals for the equipment.

4.26.4. **Coordination**.

- The SI will conduct an initial pre-submittal workshop and coordination meeting with the Contractor and Engineer to review the scope of the project and the project schedule and discuss the Department's preferences for how the system will be designed to operate.
- A submittal progress meeting will be conducted by the SI at the 50 percent complete stage with the Contractor and Engineer to discuss progress of the design and questions that may arise.
- Approximately 30 days after the 100 percent complete submittal is made, the SI will conduct a final submittal review meeting with the Contractor and Engineer to discuss final comments before system fabrication.
- The SI is responsible for coordinating the compatibility of components and equipment with the Contractor, particularly the pump motors and associated components.
- The Systems Integrator is responsible for coordinating the compatibility of components and equipment used in control systems of this Contract.
  - New Work: Should the Systems Integrator determine that there is some incompatibility regarding 2 or more components to be provided under this Contract, they must bring this issue to the Engineer's before the fifty percent (50%) complete submittal stage. The Engineer will make a decision regarding systems integration; the decision will be final.
  - Rehabilitation Work: For rehabilitation work utilizing existing components to remain, the Systems Integrator is required to develop an understanding of those existing components to the fullest extent practicable and incorporate that understanding into the integration of new and existing components. In the event the Systems Integrator determines there is some incompatibility between 1 or more existing components to remain and 1 or more new components to be provided under this Contract, they must bring this issue to the Engineer's attention before recommissioning existing components and before the fifty percent (50%) complete submittal stage for new components. The Engineer will make a decision regarding systems integration; the decision will be final.
- To ensure compatibility between instrumentation components and equipment, it is the responsibility of the Systems Integrator to coordinate interface requirements with the existing mechanical and electrical hardware and to furnish and install signal isolation devices as required to provide safe, reliable, and fully functioning control systems.
- The Systems Integrator and the Contractor must investigate each space in the building through which equipment must pass to reach its final location. If necessary, the Systems Integrator is required to ship the components in sections, sized to permit passage through such areas. The Systems Integrator and the Contractor also must investigate space and allocated access (front, rear, side); any subsequent concerns must be brought immediately to the attention of the Engineer.
- The Systems Integrator must coordinate the installation, placing, and location of system components, their connections to the process components, panels, cabinets, and devices as required to complete the work subject to the Engineer's approval.
- As this is an operating pumping station, the pumping facilities must be fully operational at all times. Coordinate work with the Department's personnel.

4.26.5. **Factory Acceptance Test**.

- The SI will conduct a factory acceptance test for the Pump Control Systems before shipment of the equipment. Conduct the factory test at the supplier's facility and demonstrate the control system was designed and performs in accordance with the Specifications and plans. Equipment furnished for the Pump Control Systems must be assembled and interwired so that it functions as a complete system for the factory acceptance test.

- The SI must provide necessary equipment and hardware required to conduct the factory test.
- The factory acceptance test must demonstrate the proper operation of control logic in accordance with the Specifications and plans, and system hardware and software. The factory test will be witnessed. Testing must occur within the 48 contiguous states. If testing is not within 2 hr. of the project site, the SI is responsible for the travel expenses of up to 2 Department representatives to witness the test. Coordinate scheduled dates with required parties.
- A detailed step-by-step test procedure for testing activities is to be delivered to Engineer not less than 60 calendar days before the scheduled start date. Engineer reserves the right to reschedule the start of the test if a proper, approved, complete test procedure is not available at least six weeks in advance of the scheduled test date.
- Confirm in writing, times, and dates two weeks before a test.
- Perform a walkthrough of equipment supplied. Utilize checklist provided as part of the test procedure documents to verify presence of required components. Note any exceptions. Engineer reserves the right to cancel remaining test activities if items are missing.
- Inspect each enclosure. Demonstrate quality of workmanship, labeling, dressing of cables, conformance of enclosures with drawings. Record comments on test procedure documents.
- Demonstrate basic PLC functions for each PLC including, but not limited to the following:
  - The System Integrator must utilize the new PLC controller in conjunction with the PLC cards, modules, backplanes, signal duplicators, and Ethernet switches specified by the Contract Documents to allow for factory testing of the new PLC programing and simulation of the interaction and communication between the individual system components and the Pump Control panel. Any additional temporary or special equipment, relays, etc. needed to fully test the system must be provided by the SI. Following testing the spare equipment must be repackaged for long term storage and turned over to the Department.
  - Exercise every I/O point served by the Pump Control Panel PLC modified under this Contract. Include spares. Provide necessary simulation equipment to simulate discrete inputs, discrete outputs, analog inputs, analog outputs, and serial communication. Simulation equipment should be provided with multiple channels to enable testing of several I/O points without need to connect or disconnect for each point.
  - Test each analog input at 0, 50%, 100% of full scale by creating proper signal (e.g. 4-20 mA or 1-5 Volts) using signal sourcing device.
  - Provide an appropriate load (light or buzzer) to test each discrete output. LEDs on DO cards are not enough as an indication of proper DO function.
  - Provide suitable meter to measure each analog output point at 0, 50 and 100% of full scale. Provide appropriate switches to simulate contact closures to test every digital input point.
  - Demonstrate UPS operation for brief power outage.
- Provide the following documentation:
  - One copy of submittals applicable to the equipment to be tested.
  - One copy of the Drawings and Specifications together with addenda and change orders.
  - One master copy of the test procedure.
  - A complete inventory of the equipment to be tested including make, model and serial number.
- Provide use of the following test equipment:
  - Input/Output Test Set: This set must be wired to representative input and output components to allow complete testing of these components.
  - Off-line diagnostic and test programs.
  - Maintenance and test equipment including, but not limited to: voltmeter, ammeter, ohmmeter, oscilloscope, electrician's tool set, and special test equipment.

4.26.6. **Record Drawings**. Submit required number of record or as-built drawings for the Pump Control Systems before the delivery of any equipment to the site. Provide an as-built drawing in the control panel.

Following start-up and commissioning of the system, the SI will make any necessary changes to the as-built drawings and re-submit required number of final as-built drawings. A final as-built drawing must also be provided in the control panel.

4.26.7. **System Installation, Start-Up, and Commissioning**.

System Installation. Perform field wiring to the equipment furnished by the SI under the electrical requirements of the Contract by the Electrical Contractor under the supervision of the Pump Control Systems Supplier.

The SI will provide on-site supervision and advice to the installing Electrical Contractor to insure the system is installed in conformance with the specifications and the manufacturer's requirements.

Field wiring may be performed by the Systems Integrator directly or may be performed by the electrical sub-contractor working under direct supervision of the Systems Integrator.

The Systems Integrator must provide on-site supervision and advice to the installing electrical sub-contractor to ensure that control systems are installed in accordance with the Specifications and the manufacturers' requirements.

- For the following connections, the Systems Integrator is responsible for ensuring that field wiring for power and signal circuits are done correctly in conformance with best industry practices to ensure satisfactory functioning installations:
- Between individual existing devices;
- Between existing devices and proposed control systems;
- Between multiple proposed control systems; and
- Within individual proposed control systems

The Systems Integrator is responsible for ensuring that control systems are installed properly, tested, and fully operational. Install and test proposed instrumentation and control systems and ensure they are operating properly before taking existing systems out of service.

System Start-Up. Submit a detailed testing and start-up plan two weeks before start-up for approval, and coordinate scheduled dates with required parties. Submit open and closed loop signal test sheets listing possible signals to be tested for review and approval.

- Conduct open loop point to point wire testing in conformance with the approved signal test sheets in the presence of the Engineer. Conduit and wiring must be installed before open loop testing.
- Conduct closed loop testing from field devices to PLC in conformance with the approved closed loop test sheets in the presence of the Engineer. The open and closed loop testing must be on separate days.
- Start-up the control system by energizing the system equipment and testing the operation of hardware, software, process control logic, and customized software programs.
- All start-up and testing must be scheduled, performed in an orderly sequence, and conducted in the presence of and to the satisfaction of the Engineer.
- Include the following information in the submittals for this section:
    - Loop checkout schedule.
    - Loop checkout procedure including sign-off forms.
    - Schedules, procedures, and sign-off forms for other tests specified.

- Supply two-way radios and cellular telephones to permit two way communications by personnel between sites for use during the field test activities. These phones and radios will be used by the Engineer and the Contractor as necessary.

Perform field testing to verify the operation of the Pump Station controls. Field tests are as follows:

- Loop tests after troubleshooting.
- Function tests.
- Integrated system test.
- Testing will begin after installation of the system components at the site. These must include:
  - PLC's.
    - Instrumentation.
    - Communications equipment required for operation of the system.
    - Other field instruments, panels, switches, termination cabinets, control devices and related interconnections.

Begin testing by performing the following steps:

- Check equipment against shop drawing list.
- Verify that the equipment has been installed in conformance with Contract Documents and manufacturer's directions.
- Power up the equipment and calibrate power supplies.
- Load applications software.

Run diagnostics to verify error-free operation.

- Check each signal wire and spares from the field element termination point to the PLC I/O terminal block. Verify end to end continuity of each wire, and that no stray voltage exists on any other wires. Verify that voltage drop through the wire from end to end is within acceptable limits, as specified. Note and correct any deficiencies.
- Verify that each wire label shows proper wire identification, is legible and that the wire designation shown on the loop drawing matches exactly the wire designation shown on the wire label. Wires must be identified at each end, including any intermediate junction points. Note and correct deficiencies.
- Provide space on the loop drawings and test sheets to hold Engineer and Contractor's signatures and dates for this test.
- Check each loop from the end element to the respective control display. Include instruments, control devices, panels, termination cabinets, input/output cards and other devices in the loop to ensure proper operation and linkage to appropriate HMI displays at station.
- Whenever possible, motion check the final control element through panels and through operator control stations. When not possible to perform a motion check, simulate the motion check at the final control element location.
- Document loop checks and submit to the Engineer. Include the following:
    - Loop number.
    - Loop description.
    - Termination information.
    - Loop drawing reference.
    - Type of tests performed.
    - Date tested.
    - Signature of tester and date.
    - Signature of Engineer and date.
    - Problem description, if any.

- Summarize loops found to contain defective or inoperable equipment on separate sheets and submit to the Engineer.
  - Correct and recheck work performed under this Contract.
  - The Engineer will coordinate correction of defective work by others, (e.g. other contractors not involved in this project) and correction of deficiencies discovered in existing wiring or instrumentation. Perform rechecking as a part of this Contract.
- Test function of the system.
  - Include a demonstration of the following maintenance and support functions:
    - System status displays and use.
    - Diagnostics.
    - Power fail/restart.
    - PLC alarming under loss of communications, loss of I/O, etc.
  - Operation of PLC on UPS backup power without AC power connected. Verify that battery has enough capacity to maintain operation of equipment for minimum period specified.
  - Test control functionality, assuring that control schemes and backup schemes work according to descriptions found elsewhere in the Contract Documents
- Document and submit tests to the Engineer, including the following.
  - Description of function.
  - Test performed.
  - Copies of messages, displays, reports, and trends which verify operation;
  - Signature of tester and date.
  - Signature of Engineer and date.
  - Problem description, if any.
- Schedule any field testing that may affect the station operation through the Engineer on a daily basis.
- The SI will not perform any testing which may affect TxDOT and station operations without the Engineer's concurrence.
- Meet the following conditions before the start of any testing:
  - Correct deficiencies noted during in-factory testing and inspections following installation.
  - Keep on-site documentation pertinent to the equipment being tested.
  - Keep on-site, labeled, and properly stored, spare parts, expendables and test equipment pertinent to the equipment being tested.
  - Keep operational field equipment supplied and pertinent to the equipment being tested.
  - Submit Engineer reviewed test schedules and test procedures.
  - Re-load PLC's and OIT's using images supplied by Contractor or Department as appropriate.
  - All installation work is complete and approved.
  - All drawings and Operation and Maintenance manuals are available for review.
- Test procedures and test results will reflect information contained within the various operation and maintenance manuals furnished. Perform no test without the appropriate manuals being followed word-for-word unless approved. Lack of acceptable manuals will be cause for declaring the test to have failed regardless of the actual test results.
- The Engineer will determine the site sequence in which testing will be performed.

4.26.8. **System Commissioning**. Supervise the factory representative's calibration for instrumentation and place the complete control system into operation. The commissioning of the system must include the overall calibration and tuning of control loops and sequences to provide stable control of the pumps. The validity of inputs and outputs for the system must be checked and corrected during the system commissioning.

The SI will provide someone on-site for the length of time necessary for system installation, start-up, and commissioning.

4.26.9. **Final Acceptance Test**. Following the commissioning of the Pump Control Systems, and the issuance of the Certificate of Substantial Completion to the Contractor, conduct a final acceptance test for a period of 30 consecutive days. This test must be scheduled with the Engineer and will not begin until the SI receives written approval to start. During that time period, the system must operate satisfactorily and in compliance with the Specifications. The SI will promptly correct any problems that occur during the final acceptance test and perform retests as necessary to verify proper operation.

Following the successful completion of the final acceptance test, a certificate of final acceptance will be issued to the System Supplier.

4.26.10. **Expansion of System I/O**. The System Supplier must include in their cost for this Contract the modification of an additional 25 system I/O points above and beyond those identified or required for completion of the Contract work. This must include costs to configure these points within the system including software programming, drawing changes, and field verification.

4.26.11. **Graphics**. The Systems supplier is responsible for developing graphics for each controlled, monitored, or integrated system to match the look and feel of the existing SCADA graphics. The Systems Integrator must provide color sample graphics for each system for review and approval.

The graphic screens must be configured in a hierarchical format to facilitate the Operator's interface to the process. The hierarchy must consist of a series of graphic screens that provide progressively more detail as the operator navigates through them. Provide a home icon to allow an operator to return to the facility overview display as described herein from any graphic screens. Graphic screens to include but not be limited to Facility Overview display, main displays, secondary displays, data displays, object displays, trend displays, and alarm displays. At a minimum, the Contractor must include the programming and creation of 25 graphical screens associated with the facility.

4.26.12. **Additional Software Configuration and Programming**. The System Supplier must include in his cost for this Contract 4 additional man-days of on-site time for software configuration and programming. The service dates will be determined in one day increments and may not be consecutive. This time will be utilized for changes or additions that may be required after the commissioning of the system. The Supplier's cost for these additional man-days must include software documentation changes and travel related expenses.

Copies of software licensing and programming requirements must be provided to the Department in digital format and printed format also.

4.26.13. **Training**. During the final acceptance test, the System Supplier must arrange for the instruction and training of TxDOT personnel in the operational procedures of the system. At the end of the training, operations personnel must have, as determined, enough knowledge to operate the system.

4.27. **Structural**.

4.27.1. **Concrete**. Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." For concrete in slabs, use Class A with Grade 3 aggregate. Place the proposed generator in the required area adjacent of expansion to pump station location, constructing a foundation slab of concrete with rebars.

- Ensure the detailing of concrete reinforcement bars and accessories conforms to the recommendations of the ACI Detailing Manual (ACI 315-80).
- Mix, transport, and place concrete in accordance with ACI 301-84 and Items 420, "Concrete Structures," and 421, "Hydraulic Cement Concrete."
- Provide standard bar chairs and spacers as required to maintain the concrete cover protection specified during rehab procedure.
- Provide 1-No. 4 reinforcement bar x 4.0 ft. at re-entrant corners and around rectangular holes in slabs unless noted otherwise. Place the bars diagonal to the corner with 1 in. clearance from the top and the side of the slab at the corner.

- Provide concrete cover protection for reinforcement bars as follows (see ACI 318 83 Section 7.7 for conditions not noted):
  - Slabs on Grade (Bottom): 3 in.
  - Slabs on Grade (Top): 3/4 in.

4.27.2. **Foundation**. Provide a subgrade under slabs that has a maximum Plasticity Index of 20 and compact in accordance with Section 132.3.D.1, "Ordinary Compaction" of the Item 132, "Embankment." A 2 to 4 in. compacted bank sand layer may be used as a level-up for the slab.

4.27.3. **Structural Steel for Wet Well**. Provide structural steel, rolled shapes and plates conforming to AASTM A 36. Ensure structural steel is hot-dipped galvanized, which are to be painted. Provide stainless steel expansion anchors that have a 4:1 safety factor with a minimum working capacity as follows:

Table 3
Expansion Anchor Requirements

Bolt Diameter (in.)	Min. Shear Strength (lb.)	Min. Pull Out Strength (in.)	Min Embedment (in.)
1/2	2080	1380	2 1/4
5/8	2975	1830	2 7/8
3/4	4280	2530	3 3/4
1	6700	4000	4 1/2

Install the expansion anchors in conformance with the manufacturer's recommendations.

Submit a list of material and specifications (AISI, ASTM, etc.) for the anchor components, as well as pull out and shear values attained from tests performed in accordance with ASTM E488 by a certified independent testing laboratory. Include the manufacturer's installation instructions in the submittal.

Detail, fabricate, and erect the structural steel in accordance with AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings," latest edition and amendments, and the AISC "Code of Standard Practice for Steel Buildings and Bridges."

Do not splice structural steel members if not detailed on the plans without the prior approval of the Engineer as to location, type of splice, and connection to be made.

4.27.4. **Wet Well Roof Access Doors**. Provide floor style access doors. Fabricate the frame from 1/4-in. thick extruded aluminum incorporating a continuous concrete anchor. Fabricate the door leaf from 1/4 in. aluminum diamond tread plate, reinforced with aluminum stiffeners designed to withstand a live load of 300 lbs. per square foot. Provide a door capable of opening to 90 degrees and locking automatically in that position with a stainless-steel hold open arm. Incorporate an enclosed stainless steel compression spring assist into the hold open arm. Provide a stainless-steel slam lock with a removable handle for securing the door. Provide a vinyl grip handle to release the cover for closing. Provide an aluminum mill finish, with a bituminous coating applied to exterior of the frame where it will meet concrete. Supply a stainless-steel lifting handle, hinges, and fastening hardware. Install as shown on the plans. Warranty the doors against defects in material and workmanship for a period of 10 yr. and supply a copy of the warranty to the Department.

4.27.5. **Construction Dewatering**. Any dewatering required during any phase of construction is the responsibility of the Contractor. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this Specification for construction dewatering.

4.28. **Facility Start-up and Demonstration Period**. When specified in individual sections of this Specification, upon completion of work for a particular section, furnish at no extra cost to the Department, the necessary manufacturer's engineers, representatives, technicians, skilled labor, and helpers and perform start-up activities as required.

4.28.1. **Start-Up**. During start-up, the manufacturer's designated personnel is responsible for fully inspecting, testing, calibrating, lubricating, operating, and certifying the equipment for which they are responsible.

When a manufacturer's representative is not required to perform start-up activities for a particular piece of equipment, the Contractor must perform any required start-up activities in strict conformance with the manufacturer's instructions.

If the Operation and Maintenance Manuals specified herein are not available at the time of the start-up, provide one copy of the manufacturer's operating literature for each system or piece of equipment. Installation and operating sheets or booklets normally shipped with equipment may be used for this purpose.

Before starting up and operating any equipment installed in the pumping station, notify the Engineer. Lubrication and starting up of the equipment must be done in the presence of and to the complete satisfaction of the Engineer, and in conformance with all manufacturer's recommendations.

The Contractor is responsible for scheduling start-up and factory testing activities for a time mutually agreeable with the Engineer and must provide a minimum of one week's notice. Complete preparatory work before to arrival of the Engineer. Start-up an testing schedule must include the times the Engineer need to be on-site. Testing may be canceled and rescheduled in the event the Contractor or any of the Contractors representatives are not prepared to start at the mutually agreed start time. The Contractor will not be due any additional time or compensation should testing need to be rescheduled. Contractor will be charged for the time lost by testing cancelations and rescheduling at the cost incurred by the Department, which will be deducted from the Contractor's monthly invoices or from monies retained under the provisions of the plans and specifications.

After all start-up activities have been completed, coordinate with the Engineer the start of the demonstrational basis for a period of 30 days.

Before starting the 30-day demonstration period, complete the following:

- Submit and get approval for shop drawings.
- Complete and submit equipment warranties and certification forms and manufacturer's certifications. Conduct and complete witness testing as required.
- Complete start-up activities
- Submit and get approval for test reports
- Submit project photographs
- Submit and get approval for Operation and Maintenance manuals.
- Conduct final walk-through of the facility with the Engineer to generate a punch-list for the project. Provide 4 weeks' notice before the desired date.
- Complete any item on the punch-list designated as requiring completion before the start of the demonstration period.
- Any item on the punch-list not designated as being required before the demonstration period must be completed before the end of the demonstration period.
- Deliver spare parts to the Engineer and submit signed receipts for record.
- Thoroughly clean the facility and complete any finished.

4.28.2. **Demonstration Period**. After the start-up items have been completed, the Engineer will issue a notice to begin the 30-day demonstration period.

During the demonstration period, conduct required training for the newly installed equipment. Training activities must be performed separately from manufacturer's start-up activities and must be held on separate days, unless approved otherwise. Coordinate schedule of training with Engineer and Department personnel. Provide a minimum 2 weeks' notice for each session.

If problems occur during the demonstration period that are designated to be significant, satisfactorily correct the problems. The 30-day demonstration period will then restart from the beginning.

After successful completion of the 30-day demonstration period, any required training, punch-list work, and final cleanup, schedule a follow-up walk through with the Engineer to verify compliance with all requirements.

5. PRODUCT SUBSTITUTION PROCEDURES

The following provide options for making product or process selections and procedures for proposing equivalent products or processes, including pre-approved, pre-qualified, and approved products or processes.

5.1. **Definitions**.

Product: Product does not include machinery and equipment used for production, fabrication, conveying, and erection of the Work. Products may also include existing materials or components designated for reuse.

Process: Any proprietary system or method for installing system components resulting in an integral, functioning part of the work. For this Item, the word "products" includes processes.

5.2. **Selection Options**.

Pre-approved products: Construction products of certain manufacturers or suppliers designated in this Item as "pre-approved." The Department maintains a list of pre-approved products. Pre-approved products for this Project are designated as pre-approved in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.

Pre-qualified products: Construction products of certain manufacturers or suppliers designated in Specifications as "pre-qualified." Pre-qualified products for this Project are designated as pre-qualified in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.

Approved products: Construction products of certain manufacturers or suppliers designated in Specifications followed by words "or approved equal." Approval of alternate products not listed in Specifications may be obtained through provisions for product options and substitutions by Engineer and by following submittal procedures. The procedure for approval of alternate products is not applicable to pre-approved or pre-qualified products.

Product compatibility: To the maximum extent possible, provide products that are of the same type or function from a single manufacturer, make, or source.

Where more than one choice is available, select product that is compatible with other products already selected, specified, or in use by the Department.

5.3. **Contractor's Responsibility**. Responsibility related to product options and substitutions is defined in these Specifications.

Furnish information the Engineer deems necessary to judge equivalency of alternate product.

Pay for laboratory testing, as well as any other review or examination costs, needed to establish equivalency between products to obtain information upon which the Engineer can base a decision.

If the Engineer determines alternate product is not equal to that named in the specifications, furnish one of the specified products.

5.4. **Department Review**. Use alternate products only when approved in writing. The Engineer's determination regarding acceptance of proposed alternate product is final.

Alternate products may be accepted if the products are judged to be equivalent to specified product or to offer substantial benefit.

5.5. **Substitution Procedure**. Collect and assemble technical information applicable to the proposed product to aid in determining equivalency as related to the approved product specified.

Submit a written request for a construction product to be considered as an alternate product.

Submit product information after the effective date of the Contract and within the time allowed for substitution submittals. After the submittal period has expired, requests for alternate products will be considered only when the specified product becomes unavailable because of conditions beyond the Contractor's control.

Submit 5 copies of each request for alternate product approval. Include the following information:

- Complete data substantiating compliance of proposed substitution with the Contract.
- For Products:
  - Product identification, including manufacturer's name and address.
  - Manufacturer's literature with product description, performance and test data, and reference standards.
  - Samples, as applicable.
  - Name and address of similar projects on which product was used and date of installation. Include names of Owner, design consultant, and installing contractor.
- For Construction Methods.
  - Detailed description of proposed method.
  - Plans illustrating methods.
- Itemized comparison of proposed substitution with product or method specified.
- Data relating to changes in the Construction Schedule.
- Relation to separate contracts, if any.
- Accurate cost data on proposed substitution in comparison with product or method specified.
- Other information requested.

Approved alternate products will be subject to the same review process as the specified product would have been for Shop Drawings, Product Data, and Samples.

6. BASIC PRODUCT REQUIREMENTS

Requirements for transportation, delivery, handling, and storage of products.

6.1. **Products**. Products do not include machinery and equipment used for preparation, fabrication, conveying and erection of the work. Products may also include existing materials or components designated for reuse.

When the plans and specifications require that installation of work, comply with manufacturer's printed instructions, obtain and distribute copies of such instructions to parties involved in installation, including 2

copies to the Engineer. Maintain one set of complete instructions at jobsite during installation until completion.

Provide products from the fewest number of manufacturers as practical, to simplify spare parts inventory and to allow for maximum interchangeability of components. For multiple components of the same size, type, or application, use the same make and model of component throughout the work.

6.2. **Transportation**. Arrange for transportation, delivery, and handling of products required for timely completion of the work. Transport and handle products in conformance with the manufacturer's instructions. Consign and address shipping documents to proper party giving name of the Project and its complete street address. Shipments are to be delivered to the Contractor.

6.3. **Delivery**. Arrange deliveries of products to accommodate short-term site completion schedules and in ample time to facilitate inspection before installation. Avoid deliveries that cause lengthy storage or overburden of limited storage space. Coordinate deliveries to avoid conflict with the work and conditions at the site and to accommodate the following:

- Work of other contractors or the Department.
- Limitations of storage space.
- Availability of equipment and personnel for handling products.
- The Department's use of premises.
- Products delivered to the site are in the manufacturer's original, unopened, labeled containers. Immediately upon delivery, inspect shipment to assure:
- Product complies with requirements of the Contract.
- Quantities are correct.
- Containers and packages are intact; labels are legible.
- Products are properly protected and undamaged.

6.4. **Product Handling**. Coordinate off-loading of products delivered to the site. If necessary during construction, move and relocate stored products at no additional cost. Provide equipment and personnel necessary to handle products, including those provided by the Department, by methods to prevent damage to products or packaging. Provide additional protection during handling as necessary to prevent breaking, scraping, marring, or otherwise damaging products or surrounding areas. Handle products in conformance with manufacturer's recommendations.

6.5. **Storage of Products**. Store and protect products in conformance with manufacturer's recommendations and requirements of these Specifications.

Make necessary provisions for safe storage of products. Place products to prevent damage to any part of the work or existing facilities and to maintain free access at all times to parts of the work and to utility service company installations in the vicinity of the work. Keep products neatly and compactly stored in locations that will cause minimum inconvenience to other contractors, public travel, adjoining owners, tenants, and occupants. Arrange storage in a manner to provide easy access for inspection.

Provide off-site storage and protection when on-site storage is not adequate. Provide addresses of, and access to, off-site storage locations for inspection.

Do not use lawns, grass plots, or other private property for storage purposes without written permission of owner or other person in possession or control of premises.

Protect stored products against loss or damage.

Neatly, safely, and compactly stack products delivered and stored along the line of the work to avoid inconvenience and damage to property owners and the general public and maintain at least 3 ft. clearance around fire hydrants. Keep public, private driveways, and street crossings open.

Repair or replace damaged lawns, sidewalks, streets, or other improvements to the satisfaction of the Engineer. The total length that products may be distributed along route of construction at one time is 1000 ft., unless otherwise approved in writing.

7. STARTING SYSTEMS

This section includes starting systems, demonstration and instructions, and testing, adjusting, and balancing.

7.1. **Preparation**. Coordinate schedule for start-up of various equipment and systems.

Notify Engineer 7 days before start-up of each item.

Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions which may cause damage.

Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.

Verify wiring and support components for equipment are complete and tested.

Execute start-up under the Contractor's supervision in conformance with the manufacturer's instructions.

When specified in specification sections, require the manufacturer to provide an authorized representative to be present at the site to inspect, check, and approve equipment or the system installation before start-up, and to supervise placing equipment or the system in operation.

Submit a written report that the equipment or system has been properly installed and is functioning correctly.

7.2. **Demonstration and Instructions**. Demonstrate operation and maintenance of products to the Engineer or their representatives 2 weeks before Substantial Completion.

Utilize operation and maintenance manuals as basis for instruction. Review contents of the manual with the Engineer or their representatives in detail to explain aspects of operation and maintenance.

Demonstrate start-up, operation, control, adjustment, troubleshooting, servicing, maintenance, and shutdown of each item of equipment at agreed-upon times, at the equipment location.

Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

7.3. **Testing, Adjusting, and Balancing**. The Contractor will appoint, employ, and pay for services of an independent firm to perform testing, adjusting, and balancing.

Reports will be submitted by the independent firm to the Engineer indicating observations and results of tests and indicating compliance or non-compliance with specified requirements and with the requirements of this Item.

8. MEASUREMENT

This Item will be measured by each complete pumping station.

9. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Automatic Pumping Station–SL 8," at the location specified. This price is full compensation for furnishing and installing a fully operational automatic pumping station and for the equipment required by this Item including buildings, generators, pumps, discharge pipes, sensors, controls, switchgear, electrical systems, wet well, furnishing temporary pumps maintaining existing pumping rate during construction and for other materials, labor, tools, equipment, accessories, and incidentals. Any costs associated with providing temporary power and electrical equipment, including but not limited to generators, panel boards, wiring, and starters to keep existing station in operation during construction, dewatering, electrical service, and testing are subsidiary to this Item. The work performed, materials furnished, equipment, labor, tools, and incidentals for construction of the wet well will not be paid for directly but are subsidiary to this Item.

Any dewatering required during any phase of construction is the responsibility of the Contractor and is subsidiary to this Item. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this Specification for construction dewatering.

Special Specification 7363
Automatic Pumping Station

1. DESCRIPTION

Furnish labor, materials, and equipment necessary to construct a stormwater pumping station at IH 45 and Cullen Blvd. as shown on the plans that is complete, functional, and fully automatic consisting of, but not limited to the following components.

2. APPROVALS

Upon approval of the above items, construct the pumping station or any portion of it pertaining to the approved items.

If an approved item requires dimensional changes or alterations of the project plans, prepare at no expense to the Department, the necessary plans and submit electronically for approval. Upon approval, proceed with that portion of the pumping station affected by the change.

No changes are permitted in the list of equipment or shop drawings once approved, unless authorized in writing. Approved equipment and plans constitute final plans for construction of the pumping station. Approval, in no way relieves the Contractor or equipment suppliers of any responsibilities described elsewhere in these specifications.

3. OPERATIONS AND MAINTENANCE MANUALS

Upon determination of the equipment to be used in this station and before final acceptance of this project, furnish the Engineer 3 books binders each containing the following:

Submit documents with 8-1/2 in. x 11 in. pages, bound in 3-ring or D binders with durable plastic covers. Subdivide contents with permanent page dividers, logically organized to the Table of Contents, with tab titling clearly printed under reinforced laminated plastic tabs. Prepare a Table of Contents for each volume, with each product or system description identified.

Part 1–Directory: Listing of names, addresses, and telephone numbers of Design Consultant, Contractor, Subcontractors, and major equipment suppliers.

Part 2–Operation and maintenance instructions, arranged by system. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers and include the following.

- Significant design criteria;
- List of Equipment;
- Parts list for each component;
- Operating instructions;
- Maintenance instructions for equipment and systems; and
- Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

Part 3–Project documents and certificates, including the following.

- Shop drawings and product data,
- Air and water balance reports,
- Certificates, and
- Photocopies of warranties.

Equipment Operation and Maintenance (O&M) Data–Furnish O&M Manuals, prepared by manufacturers for provided equipment. Manuals must contain at least the following items.

- Equipment functions, normal operating characteristics and limiting conditions;
- Assembly, installation, alignment, adjustment, and checking instructions;
- Operating instructions for start-up, normal operation, regulation and control, normal shutdown, and emergency shutdown; and
- Lubrication and detailed maintenance instructions. Maintenance instructions are to include detailed plans giving location of each maintainable part and lubrication point and detailed instructions on disassembly and reassembly of equipment.

- Troubleshooting guide;
- Complete spare parts list with predicted life of parts subject to wear, lists of spare parts recommended on hand for both initial start-up and for normal operating inventory, and local or nearest source of spare parts availability.
- Outline, cross-section, and assembly plans; engineering data; wiring diagram;
- Test data and performance curves;
- The complete sequence and full description of operating instructions, noting precautions; and
- Bound copies of warranties and guarantees with dates of expiration, also names and addresses of persons providing warranties and guarantees.

4. COMPONENTS

4.1. **Basic Mechanical Materials and Methods**. Provide complete mechanical systems, including miscellaneous materials, and ready for operation in conformance with the plans and specifications.

4.1.1. **Quality Assurance**.

- **Materials and Equipment**: Use standard products of manufacturers regularly engaged in production of such materials and equipment, unless otherwise indicated.
- **Design**: Use manufacturer's latest standard design in accordance with this Item.
- When two or more units of same class of equipment are required, supply products from the same manufacturer.
- Where materials and equipment are specified to meet requirements of standards or organizations such as Underwriters Laboratories (UL), American Society for Mechanical Engineers (ASME), etc. that use a label or listing as a method of indicating compliance, such label or listing must be attached to the material or equipment when delivered to the jobsite.
- Each major component of equipment must have the manufacturer's name, address, and model number on a metal nameplate American Welding Society (AWS) certified.
  - Structural and miscellaneous fabricated steel used in equipment must conform to AISC standards, except where otherwise specified,.
- Design structural members for appropriate shock and vibratory loads.
  - Steel partially or totally submerged during operation of equipment must be at least 1/4 in. thick, unless otherwise specified.
  - Materials and Workmanship must conform to standards of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

4.1.2. **Submittals**. The following items are required as part of the submittals.

4.1.2.1. **Product Data**. Submit data for materials other than manufacturers' standard products.

4.1.2.2. **Shop Drawings**. Include descriptive and published details concerning performance, capacity, and noise ratings for each piece of equipment.

- For electrical motor-driven equipment, include schematic drawings showing coordination with electrical system including rated horsepower and full load current requirements.
- For electric motors 3/4 Horsepower and larger, furnish the following information:
  - Locked rotor current,
  - Power factor at full and 3/4 load,
  - Efficiency at full load and rated operation condition,
  - Type of bearings,
  - Lubrication requirements,
  - Net weight, and

- Catalog data for materials other than equipment that are manufacturer's standard products.
- Provide scaled mechanical layout drawings showing:
  - dimensioned plan views and elevations of mechanical equipment,
  - equipment mounting and foundations, including anchoring details,
  - piping and duct work, including support detail, and
  - components, including space requirements, coordination with building features, and other work.

4.1.2.3. **Quality Assurance and Control Submittals**. Supply manufacturer's instructions and recommendations for installation, handling and storage, and cleaning and maintenance of equipment and materials during storage and before initial energizing.

4.1.2.4. Certificates.

- General: Provide manufacturer's certificates for material and equipment listed.
  - Pipe, fittings, and valves 8 in. and smaller in diameter.
  - Pipe, fittings, and valves larger than 8-in. diameter: Follow individual specification sections for submittal requirements.
- Welding: Provide evidence that each welder is certified for type of welding required following AWS.

4.1.3. **Delivery Storage and Handling**.

4.1.3.1. Packing, Shipping, Handling, and Unloading.

Materials and Equipment: Box, crate, or otherwise completely enclose and protect during shipment, handling, and storage, and clearly label with manufacturer's name, brand, or model designation, type or grade, and color.

Packing Lists and Bills: Include complete packing lists and bills with each shipment.

Tagging and Marking: Each item of equipment tagged or marked with same identification number or mark shown on packing lists and bills of material.

4.1.3.2. **Storage and Protection**. Protect materials and equipment from exposure to elements and keep dry. Handle and store to prevent damage, following manufacturers' recommendations.

- Protect insulation, controls, and electrical equipment from moisture and water damage.
- Store pumps, motors, electrical, and other equipment with antifriction or sleeve bearings in weather tight areas maintained above 60°F.

Space Heaters Furnished in Equipment: Connected during storage and operated continuously.

Protect equipment and material from rust, pitting, decay, or other deleterious effects from storage and handling. Repair or replace material and equipment showing such effects or damage, as directed.

4.1.4. **Project Conditions**.

- General: The plans indicate extent and general arrangement of equipment, piping, and ductwork.
  - Fit equipment into space allotted and allow adequate clearance for entry, installation, replacement, servicing, and maintenance.
  - Verify actual and final arrangement, location, grades, and elevations of equipment, appurtenances, piping, and ducts before ordering material and equipment.
- If adjustments and modifications are necessary, submit to Engineer details of such adjustments and modifications and reasons for approval as soon as practicable, but at latest with submittal of scaled mechanical layout drawings.

- Make no adjustments or modifications without Engineer's written approval.
- Coordinate work so equipment may be moved into place without altering building components, other equipment, or installations. Provide drops, rises, or offsets required for proper installation, whether or not shown on plans.

4.1.5. **Safety Requirements**.

- Enclose or provide guards for belts, pulleys, chains, gears, and other rotating parts to protect operating personnel.
- Guard or cover high-temperature equipment and piping with insulation to protect personnel and prevent fire hazards.
- Provide items such as catwalks, ladders, and guardrails, where required, for safe operation and maintenance of equipment.
- Provide safe working space around equipment.

4.1.6. **Sequencing and Scheduling**. Coordinate sequencing and scheduling of mechanical work with building construction and other related parts of work, including verification that structures, piping, wiring, conduits, and equipment components are compatible.

4.1.7. **Maintenance Materials**. Spare parts and extra materials are specified in the specific Section for equipment or materials.

- Pack into wooden boxes parts listed to be furnished, and label with:
  - manufacturer’s name, address, and telephone number; and
  - local representative's name, address, and telephone number.
- Names of equipment parts are for and list of parts contained within them.
- Pack extra material in strong cartons, labeled with manufacturer's name, material name, type, color, and location material was installed. Store maintenance material in a location directed.

4.1.8. **Manufacturer Services**.

- Ensure manufacturer’s field representatives of furnished equipment are onsite during installation, start up, tests, and to instruct the Department personnel on operation and maintenance of equipment.
- Ensure Factory trained service and operating personnel are available to observe, instruct, guide, and direct Contractor's handling, installation, start up, and adjustment procedures of equipment.
- Manufacturer's Services:
  - Inspect equipment installed following manufacturer's instructions before but energizing or operating it and supervise equipment start up.
  - Before and during required tests, operate and adjust equipment following plans and specifications.
  - When required in specification sections for equipment, instruct Department personnel in operation and maintenance of equipment at times and locations approved.

4.1.9. **Products**.

4.1.9.1. General.

- In design and supply of equipment, ensure interchangeability of parts and items for equipment, piping, ductwork, motors, and other appurtenances.
- Factory assemble, coat, and paint mechanical equipment as much as practicable before shipping and handling with factory-applied prime coat.
- Nameplate: Attach to each major component of equipment a metal nameplate showing manufacturer's name, address, and equipment model number.

4.1.9.2. Equipment Bases.

- **Concrete Bases**: Unless otherwise indicated, concrete bases must be at least 4-in. thick, and not less than 4-in. larger in both directions than supported unit.
- **Cast Iron or Welded Steel Baseplates**: Support each unit and its drive assembly on a single baseplate.

4.1.9.3. Anchor Bolts.

- Provide anchor bolts, nuts, and washers that are stainless steel, Type 304.
- Unless otherwise indicated, size anchor bolts to largest diameter that will pass through bolt holes of equipment base.
- **Length of Bolts**: To permit at least 1-in. of grout beneath base plate and at least of 6-in. anchorage into structural concrete.
- **Template or Setting Drawing for Anchor Bolts, Nuts, and Washers**: Furnish sufficiently in advance to permit anchor bolts to be set either before or during structural concrete placement.

4.1.9.4. **Supports and Braces**. Provide supports and braces fabricated to meet manufacturer's requirements and as indicated on the plans.

4.1.9.5. **Drive Units**. Provide units that meet the following specifications.

- **Nominal Input Horsepower Rating of Gears or Speed Reducers**: At least equal to nameplate horsepower of drive motor.
- **Drive Units**: Designed for 24-hr. continuous service.
- **Motor and Drive Gears**: Rated AGMA Class II and bearing AGMA nameplate.
- **Gear Reducers**: Totally enclosed, oil lubricated, with antifriction bearings throughout.
  - Worm Gear Reducers: Service factor of at least 1.20.
  - Shaft-mounted Gear Reducers: Rated AGMA Class II.
  - Other Helical, Spiral Bevel, and Combination Bevel-helical Gear Reducers: Service factor of at least 1.50.
  - Gear Reducer Nameplate: AGMA.
- **V-belt Drive**: Service factor of at least 1.60 at maximum speed, with sliding base or other suitable tension adjustment mechanism.
- **Variable Speed Drives**: Service factor of at least 1.75 at maximum speed, unless specified otherwise.

4.1.9.6. **Coupling, Bearings, Journals, and Keys**. Provide items that meet the following specifications.

- **Couplings**: Where specified or required between motor and its driven equipment, use flexible standard self-aligning forged steel coupling.
  - Fix and key 1 hub of coupling to driven equipment shaft with other hub fixed and keyed to abutting drive shaft.
  - Place moisture and dust-proof metal coupling as close as possible to driven equipment and motor bearings so units are arranged in compact manner.
- **Bearings**: Ball or roller type, with both inner and outer races and balls or rollers made from heat-treated steel, and pressure-grease lubricated, except those specifically requiring lubrication.
- **Rollers**: Proper size to carry maximum loads without flaking, spalling, or crushing.
  - Balls: Evenly spaced and held in position by continuous spacing or retainer glands.
- **Journals and Bearings**: Sized and of proportions to create least wear and overheating under all conditions.
  - Easy Removal and Adjustment: Where required, make provisions for easy removal and adjustments.
- **Journal Lining**: When required, line with babbitt metal hammered into grooves and bored in place.
- **Keys, Nuts, and Other Parts**: Secure parts, which may work loose with locking devices.

4.1.9.7. Flanges, Jacking Screws, and Eye Bolts.

- **Flange Bolt holes**: Drilled with flanges spot-faced on back and stud holes not drilled through.
- **Jacking Screws**: For covers, where required.
- **Eye Bolts for Lifting Covers and Equipment**: When manual lifting would be difficult, or where required.

4.1.9.8. Bolts, Nuts, and Washers.

- Provide cold pressed nuts.
- For bolts, nuts, and threads, provide American Standard sizes except those used for flanged pipe, valves, fittings, and equipment connections or otherwise noted.

4.1.9.9. Safety Guards.

- Cover belt and chain drives, fan blades, couplings, shafts, and other moving and rotating parts on every side by safety guard following OSHA requirements.
- **Fabrication**: Galvanized or aluminum clad sheet steel or 1/2-in. mesh galvanized expanded metal, 16 gauge or heavier.
- Design for easy installation and removal, with necessary supports and accessories including bolts.
- **Outdoor Guards**:
  - Design safety guards in outdoor locations to prevent entrance of rain and dripping water.
  - Safety guards: Follow OSHA requirements.
- **Supports and accessories, including bolts**: Galvanized or painted following these specifications and as required.

4.1.9.10. **Access Doors and Panels on Mechanical Equipment**. Provide access doors and panels for easy access to mechanical components that require periodic maintenance and lubrication.

4.1.9.11. Lubrication.

- **Equipment Lubrication System**: Design for weekly adjustment during continuous operation.
  - Lubrication Facilities, Oil Drains, and Fill Openings: Accessible from normal operating area or platform.
  - Drain Ports: Allow for collection of waste oil in containers from operating area or platform without removing unit from its installed position.
- **Pressure Grease Fittings**: Zerk Hydraulic or Alemite type.
  - Location: Accessible for lubricating with grease gun.

4.1.9.12. **Shop Painting**. Prepare surfaces and shop coat equipment, supports, piping, duct work, and appurtenances as specified in this Specification and as shown on the plans, except connecting ends and where it would hinder installation, using shop primer compatible with field coat. Field paint these points after installation.

4.1.9.13. **Special Tools and Accessories**. Where required for adjusting, maintaining, or repairing equipment, including special devices for lifting and handling, such special tools and accessories must be provided complete with the equipment.

4.1.9.14. **Electrical Service**. Mechanical equipment requiring electrical power to operate must be rated for electrical service as shown on the plans and must have enough length of cable and other appurtenances necessary to provide an operational and full functional unit.

If the electrical service is not shown on the plans, the Contractor is still responsible for providing such services as required by the equipment manufacturer at no additional cost to the Department.

4.1.9.15. Examination and Preparation.

- Inspect areas and surfaces to receive mechanical equipment piping, duct work, and appurtenances, and verify readiness for installation.
- Before installing, repair defects and damaged area, and adjust surfaces and areas for proper installation.
- Field measure and verify adequacy of areas to be occupied by mechanical equipment and appurtenances following approved plans.
- If adjustment is required, obtain Engineer's approval and adjust as approved.

4.1.9.16. **Installation**. Install equipment and appurtenances following manufacturer's instructions. Provide complete final connections to equipment, including pipe, duct, electricity, and controls.

Isolation Valves and Accessory Fittings: Whether shown or not, install on each side of equipment to allow it to be removed and isolated for servicing. Install manual vents at high points in piping and fit for hose adapters at low points in fluid piping. Install rises and drops as required by field conditions.

4.1.9.17. Foundations, Bases, and Supports.

- **General**: Support equipment, ductwork, electrical conduits, and piping by providing compatible frames, braces, hangers, and anchors.
- **Floor-Mounted Equipment**: Unless otherwise shown on plans, place floor mounted equipment on reinforced concrete pads at least 4-in. high.
- **Horizontal and Vertical Pumps Mounted on Baseplates or Pedestals**: Install following Hydraulic Institute Standards and pump manufacturer's recommendations.
  - Leveling of Baseplate or Pedestal: Use shims or wedges and anchor raised vibratory absorption concrete pad with anchor bolts set in pipe sleeves.
  - Grouting: Fill space between baseplate or pedestal and concrete pad, and void between anchor bolt and pipe sleeve with quick setting and non-shrink grout.
  - Tighten Bolts: After grout has hardened, tighten anchor bolts to equipment manufacturer's recommendations and cut off bolts not more than 1-in. nor less than 1/2-in. above anchor bolt nut.
- Install vibration isolators between equipment base and raised concrete pads on other vibrating or rotating mechanical floor-mounted equipment like fans.
- Anchor heavy-duty centrifugal air compressors and blowers following equipment manufacturer's recommendations.
- Non-vibratory equipment suspended inside buildings should be braced and supported for rigid installation.
  - Attach supports and hangers to bearing walls, roof, and floor supports, or framing members.
  - Install cross bracing as required to develop rigid installation.
- Suspended vibratory equipment should be braced, supported, and provided with cushioning and anti-vibratory material as shown on plans and as recommended by equipment manufacturer.

4.1.9.18. **Access Panels and Doors for Concealed Equipment**. Provide access panels or hinged doors where necessary for maintenance and servicing of concealed equipment, piping, ductwork, and fans.

4.1.9.19. **Lubrication**. Lubricate following manufacturer's instructions for initial operation; relubricate following testing and before final acceptance, if directed.

4.1.9.20. **Adjustment and Initial Operation of Equipment**. Before systems and equipment are initially started, clean piping, ductwork, and equipment.

- Check moving parts for freedom of movement, alignment, and adjustment, and
- Remove air handling units' temporary filters, check permanent filters and replace if dirty or damaged.

Manufacturer's Equipment Service: Adjust as required and recommended by manufacturer's representative and as required herein, before equipment is energized and operated.

4.1.9.21. **Surface Touch-up and Field Painting**. Clean field-installed bolts, nuts, washers, and support systems and paint or coat using materials identical to original shop coat and surrounding area. Touch up other surfaces where shop coats have been damaged, using paint, coatings, and film thickness identical to original shop coats. Apply field paint as specified and as shown on the plans.

4.1.9.22. **Cleaning and Protection**. Clean equipment, surrounding area, and ductwork inside and out. Protect equipment during and after installation from construction dust and debris. Provide temporary protection as required until equipment is in operation or until receipt of Certificate of Substantial Completion.

4.1.9.23. **Field Quality Control**. Demonstrate and test operation of systems and equipment for specified requirements, in Engineer's presence, following requirements of this Item. Adjust and replace defective equipment and parts as required.

4.1.9.24. **Operation Instructions**. After systems have met field quality control requirements and before issuance of Certificate of Substantial Completion, furnish manufacturer's services for operation and maintenance, as specified for equipment in specific sections.

4.2. **Storm Water Pumps**. Provide labor, materials, equipment, and services necessary to install, test, and place in operation two submersible mixed-flow type pumps with explosion proof motors, with column pipes, and cable suspension system shown on the plans and specified herein. Orient the units and other physical characteristics as shown on the plans. Pump motors must be explosion proof and be capable of running on variable-frequency drives (VFD) and soft-starts.

The physical size and weight of the pumps furnished must be capable of being installed in the wet well, as shown on the plans. There are limitations as to the size and weight of pump that will be able to be installed. No additional compensation will be paid for installation of the pumps. Contractor is responsible for any damage that may occur to a pump during installation and is responsible for repair or replacement to the satisfaction of the Engineer at no additional cost to the Department.

During construction activities, furnish temporary pumps to maintain the existing pumping rate. Provide necessary design and equipment for the temporary pump.

4.2.1. **Shop Drawings**. Only complete submittal packages including mechanical, electrical, structural, controls, and instrumentation equipment will be reviewed. Partial submittal packages will be returned to the Contractor without review.

Submit the following required information for pumps, motors and supports.

- **General**:
  - Dimensions
  - Details of construction and installation
- **Motor data**:
  - Manufacturer
  - Model
  - Rated horsepower
  - Efficiency
  - Service factor
  - Current and load data
  - Bearing type
  - Bearing calculations
  - Weight

- **Pump data**:
  - Manufacturer
  - Model
  - Certified performance curves with operating points plotted on curves
  - NPSH curves
- **Rated capacities**:
  - Furnished specialties and accessories
  - Materials of construction
  - Pump orientation
  - Bearing types and lubrication equipment information
  - Seal types
  - Weight
- Pump Start-up and Testing Plan
- Vibration Testing Qualifications
- Operation and Maintenance Manuals

Submit for pumping equipment.

- Equipment function, normal operating characteristics, and limiting conditions;
- Assembly, installation, alignment, adjustment, and checking instructions;
- Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions;
- Lubrication and maintenance instructions;
- Guide to “troubleshooting;”
- Parts lists and predicted life of parts subject to wear;
- Outline, cross-sections, assembly drawings, engineering data and wiring diagrams; and
- Test data and performance curves

4.2.2. **References**.

- ASTM A48–Standard Specification for Gray Iron Castings
- ASTM A743–Standard Specification for Iron-Chromium Nickel, Corrosion Resistant
- ANSI B16.1–Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125lb.
- HI 14.6–Hydrodynamic Pumps for Hydraulic Performance Acceptance Tests
- HI 11.6–Submersible Pump Tests

4.2.3. **Quality Assurance**.

Design and construct the pumps in conformance with standards of the Hydraulic Institute (HI). The efficiency of the pumps, when operating under conditions of the specified capacities and heads, must be as near peak efficiency as practicable.

Obtain pumping equipment, motors, and appurtenances from a single pump supplier whose responsibility it is to ensure that the pumping equipment is properly coordinated and operated in accordance with these Specifications.

Design and construct mechanical and electrical equipment in conformance with the latest editions of ANSI, HI, and NEMA Standards.

Submit shop drawings certified for construction by the pump manufacturer which includes location of electrical connections; wiring diagrams; anchor bolt layout; details indicating construction and materials of construction; diameter of shafting; gear and bearing ratings; installation drawings showing each pump,

suction and discharge piping and fittings, specials, supports, concrete pads, clearances, and dimensions to install the pump in the spaces indicated on the plans.

Qualifications: The manufacturer must have 20 or more years of experience and furnished similar equipment for at least five pumping stations.

4.2.4. **Vibration Limits**. The amplitude of vibration of any centrifugal pumping unit, when operating at any of the speeds specified herein must not exceed the requirements set forth in the latest revision of the Hydraulics Institute Standards. The amplitude of vibration for other pumping units must not exceed the requirements of the pump manufacturer's standard.

4.2.5. **Name Plates**. Provide each pump with a stainless-steel nameplate, riveted or bolted to the unit with stainless steel hardware. Nameplates must contain the manufacturer's name, equipment size (i.e., HP, impeller diameter, speed, flow, and head, etc.) and type, serial number, and other pertinent data specified herein.

4.2.6. **Delivery, Storage and Handling**.

Preparation for Shipment: Pieces must be delivered in the largest sizes practical for ease of installation within the existing building and ease of minimal field assembly by the Contractor. Permanently tag individual pieces tagged with welded erection marks or stainless-steel tags cross-referenced with information on the manufacturer's erection and assembly drawings. Design field connections for static, live and erection loads.

Protect drive units, mechanical and electrical components from the weather and suitably packaged to facilitate handling and storage. Provide special lubricating and rust preventative oils to prevent internal corrosion of gear assemblies. Keep mechanical equipment thoroughly dry and store indoors. Protect equipment stored on the job and maintain in conformance with the manufacturer's recommendations. When requested, provide written certification from manufacturer that the equipment is being properly stored.

Store pumps onsite under cover in accordance with this Item.

4.2.7. **Rejected material and replacements**. Reject damaged, deteriorated, or contaminated material and immediately remove from the site. Replace rejected materials with new materials at no additional cost.

4.2.8. **Field Services and Warranty**. Provide services of a manufacturer's representative for not less than 2 days onsite for installation inspection and field testing for each pump.

The Engineer has sole discretion to rearrange the configuration of the days of site support. Site visits not used by the manufacturer during the construction period must be made available to the Engineer during the warranty and operations period, not to exceed 2 yr. from the date of conditional acceptance.

Confirm each site visit in writing by a daily log signed and the manufacturer's representative. Failure of the manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit and will not be attributed to the completion of the total specified number of site visits.

Manufacturer's Warranty. Provide a warranty for a period of 5 yr., with no hour limitation, non-prorated, from the date of final acceptance. The warranty must cover pumps and motors against defects in materials and workmanship, including parts and factory or authorized service facility labor.

4.2.8.1. **Spare Parts**. Contractor must provide the following spare parts per pump.

- Impeller
- Wear Rings, one of each type
- Mechanical Seal
- One thermal sensor (RTD) per installed location

4.2.9. **Products–Stormwater Pumps**.

- Design pump units for installation into a discharge column onto a seat at the bottom of the column that are held in place by its own weight and the pumping head weight. It must be possible to lower the pump in the column and put into operation even when column is filled with water. Ensure there is no need for personal to enter the wet well when removing or reinstalling the pump. The pump must not require any bolts, nuts, or fasteners for connection to the discharge column. Provide an O-ring on the bottom of the inlet (suction) bell mouth so that the weight of the pump unit, when acting on the O-ring, will provide an effective seal between pump and discharge column.
- Provide a motor and pump manufactured by the same manufacturer.
- Coordinate the maximum outer diameter of the pump housing with the installed application. Where the pump is installed in an existing wet well, the pump column must not exceed the existing opening size. Install a locking device, located on the external surface of the pump housing, that prohibits rotational movement of the pump or motor unit within the tube.
- Equip each pump with submersible electric motor, capable to operate on a 460 V, 3 phase, 60 hertz voltage supply. The motor must be inverter duty rated for use with VFD and reduced voltage soft starters.
- The pump must be capable to transport river water and 2-in. screened storm sewer.
- Impeller must be made of cast iron, dynamically balanced, multiple-vane, double shrouded non clogging design. It must be equipped with a stainless-steel wear ring.
- Equip the suction inlet of the pump housing with a bronze wear ring.
- The outlet must have guide vanes designed to minimize clogging by carrying debris normally prone to clog the guide vanes from the inside of the guide vanes towards the outside of the guide vane. Here the flow must be partially and deliberately destabilized to help material disengage itself from the vanes, to continue its passage through and out of the pump.
- **Performance Requirements**:

Flow	4,500 gpm
Head	31.04 ft
Motor Horsepower (maximum)	70 hp
Motor Speed (maximum)	880 rpm
Pump Efficiency	72%

- The NPSHR must be below 9 ft.
- The impeller must be mounted on the motor shaft. Couplings or gear boxes will not be accepted.
- The motor must be induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. It must be permanently submersible according standard International Electrotechnical Commission IEC 60034 and protection class IP 68.
- Provide a motor cooled by the pumped water flowing along the stator housing when the pump is working. A water jacket or any external cooling system are not considered acceptable designs.
- Provide a motor capable of at least 15 evenly spaced starts per hour and be able to operate throughout the entire pump performance curve from shut-off through run-out. To limit mechanical stress to the motor and the power transmission equipment the start current must be enough to start the driven load at a maximum 3.5 x FLC.
- Provide a stator insulated according to moisture resistant Class H rated for 356°F. The stator windings must be insulated with monomer-free polyester resin resulting in a winding fill rate of at least 96%. The design must be inverter duty rated in accordance with NEMA MG1, Part 31.
- Provide a junction chamber containing the terminal board that is hermetically sealed from the motor by an elastomeric compression seal. Make the connection between the cable conductors and stator leads ith threaded compression type binding posts permanently affixed to a terminal board.
- Motor Protection: The motor must motor must be protected by following sensors:

- 3 bi-metal Thermal switches for thermal control of the stator
- 1 PT 100 thermal sensor (RTD) to monitor the stator temperature of 1 Winding
- 1 PT 100 thermal sensor (RTD) to monitor the temperature of the main bearing
- 1 Vibration sensor to monitor vibration on 3 axes from 10 – 600 Hz
- 1 float switch in leakage chamber to monitor leakage in the leakage chamber
- 1 float switch in the terminal connection housing to monitor any leakage thru the cables and the cable entries

- Furnish a pump with a pump electronic module (PEM) mounted inside the motor. The PEM must collect, store, and digitize measurements from the sensors and communicate the data in a digital format via two control leads integral to the pump power cable to a base unit mounted in a pump control cabinet to the central control unit. The pump may have no more than one cable entry including power and communication.
- The PEM must also supply information about the pump as well as features for start-up and service support, such as:
  - Pump serial number and other data plate information.
  - Specific configuration of monitoring functions for the actual pump such as alarm limits, delays, reset types, etc.
- Counters by which the system can generate service reminders in conformance with the service policy specified in the pump manual.
  - Operating data and alarm history to analyze the condition of the pump and enable troubleshooting and reporting.
  - Accumulated running time and number of starts.
  - Pump duty rate (percentage of operation).
- Provide a cable entry consisting of dual cylindrical elastomer sleeves, flanked by washers, with a close tolerance fit against the cable and the cable entry. Epoxies, silicones, or other secondary sealing systems are not considered acceptable.
- The pump shaft must rotate on at least three grease-lubricated bearings. The upper bearing, provided for radial forces, must be a single roller bearing. The lower bearings must consist of at least one roller bearing for radial forces and one or two angular contact ball bearings for axial thrust. The L10 bearing life must be at least 100,000 hr. at any point along the usable portion of the pump curve at maximum product speed. The lower bearing housing must include a thermal sensor (RTD) of the platinum-100 type to monitor the temperature of the thrust bearing outer race during operation temperature. If a high temperature occurs, the sensor must activate an alarm. The upper support bearing must have an insulated outer ring to provide protection against electrically induced currents that can be created when the motor is used with a VFD.
- Furnish a shaft seal that is positively driven dual, tandem mechanical shaft seal system consisting of two seals, each with an independent spring system. The seal is in a separate lubricant chamber and is lubricated and cooled by environmental friendly medical white oil. The lubricant chamber must be designed to prevent over-filling and must provide capacity for lubricant expansion. It must have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seal system must not rely upon the pumped media for lubrication. The seals must require neither maintenance nor adjustment and must be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal function. The rotating inner seal ring must have small back-swept grooves laser inscribed upon its face to act as a micro pump as it rotates, returning any fluid that should enter the dry motor chamber back into the lubricant chamber. Shaft seals without positively driven tandem mechanical seal or conventional double mechanical seals that are either carried out with a common single or double spring are not acceptable. Any leakage passing the sealing must not pass the bearings. Before it reaches the bearings the liquid must create an alarm via the floating leakage sensor.

- The materials of construction must meet the following specifications.
  - Pump housing & Inlet Cone: ASTM A-48, Class 35B
  - Impeller: Cast iron ASTM A-48, Class 35B
  - Rotating wear ring: stainless steel
  - Stationary wear ring: Bronze ASTM B271+B505/C 83600
  - Stator housing: ASTM A-48, Class 35B
  - Shaft: ASTM A479 S43100-T.
  - Shaft seal: Pump side: Corrosion resistant Tungsten carbide (WCCR)
  - Shaft seal Motor side: - Corrosion resistant Tungsten carbide (WCCR)
- Castings must be blasted before coating. Wet surfaces are to be coated with two-pack oxirane-ester Duasolid 50. The total layer thickness must be at least 120 microns. Zink dust primer must not be used.
- Equip the motor with screened cable suitable for submersible pump applications. Coordinate cable length with field installation requirements. Size the power cable according to NEC and ICEA standards. The outer jacket of the cable must consist of oil resistant chlorinated polyethylene rubber. The cable must be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 ft. Supply a cable support grip with the cable.
- **Pump Retrieval System**. Incorporate the Pump Retrieval System into the pump design. Furnish a pump capable of being removed by a single Type 304 stainless steel wire rope and lifted easily, securely, and safely in one continuous motion. Provide properly sized stainless steel thimble eyes and shackles. Provide a wire rope assembly with at least a safety factor of 3:1 based on the breaking strength of the wire rope and the weight of the pump. Submit the lifting technique for approval. Use stainless steel hardware.
- **Pump Column and Discharge Pipe**. Use steel pipe per ASTM A 53 Type E, Grade A or B, API-5L, or ASTM A36 rolled and seam welded plate, sized as shown on plans.
- **Weld Flanges**. Supply 125 lb., flat face, slip-on registered machined steel in accordance with AWWA C207, Class B. Use full face flange gaskets made of neoprene rubber.
- Provide protective pipe coatings suitable for immersion service. Prepare surfaces per the manufacturer's requirements. Provide one coat Series V69 Hi-build Epoxoline II at 3-4 mils dry film thickness (DFT) and two coats Series 435 Perma-glaze at 7-9 DFT per coat as manufactured by Tnemec or equivalent system. Apply one coat: Phenoline 311 at 2-3 mils DFT and one coat Plastie 4500S at 45-55mils DFT as provided by Carboline or approved equal. Provide color chart for Department selection.
- **Gaskets**. Provide 125 lb., full face, neoprene rubber gaskets.
- **Bolts**. Use ASTM A 193-B7 hex head bolts with ASTM A194-2H nuts, hot dip galvanized.
- **Adapter Flange**. Use mechanical joint type adapter flanges, manufactured from ductile iron, ASTM A536 Grade 65-45-12, Class 125, Series 400 Uni-Flange with set screws and SBR (Buna-S) gasket. Use a galvanized flange.
- **T-bolt Hinged Closure**. Proved a closure made of carbon steel with a semi-ellipsoidal head hinged to a matching hub prepared for welding to the pipe column, with a self-energizing Buna-N O-ring and a suitable number of T-bolts to effect and maintain a tight seal and is rated at 90 psi min. at 250°F. Ensure it is quickly and easily opened with the cover swung back on its hinges to allow complete and unrestricted access. Supply T-bolts with attached break-over wrenches. Provide a hot dip galvanized closure with proper size pipe couplings for pump cables welded in place.
- Supply pumps from the one of the following manufacturers: Flygt Model LL3356, KSB, or approved equal. Pump basis of design is Flygt. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the Contractor with no extra cost to the Department.

4.2.10. **Execution**.

4.2.10.1. **Installation**. Install the pumping systems in complete compliance with applicable requirements of the latest edition of ANSI/HI and the manufacturer's recommendations. Remove the existing sump pumps from operation before initiation of activities within an area. Install and maintain temporary sump pumps for the duration of construction activities within an area.

4.2.10.2. **Startup Services and Training**. The manufacturer must furnish the service of a qualified, factory-trained service representative who must inspect the complete equipment installation under the supervision of the Pump Control System Supplier to ensure that it is installed in conformance with the manufacturer's recommendations, make adjustments necessary to place the system in trouble-free operation, and instruct the operating personnel in the proper maintenance and operation of the equipment furnished.

The Department reserves the right to videotape and archive start-up and training instruction provided by the manufacturer or authorized representative.

After the pumps have been completely installed and wired, the manufacturer's service representative must perform the following.

- Megger stator and power cables
- Check seal lubrication.
- Check for proper rotation.
- Check power supply voltage.
- Measure motor operating load and no-load current.
- Check level control operation and sequence.
- Make adjustments, as necessary.

Furnish in writing a start-up report providing measurements and readings, confirming checks and inspections, indicating adjustments made, and certifying that the installation and operation is in compliance with the specifications and the pump manufacturer's recommendations. The manufacturer's representative must provide tools and test equipment required to perform testing. Should the manufacturer's representative fail to provide the necessary testing equipment, the start-up will be rescheduled at the Contractor's expense. The Contractor will not be entitled to additional time or money due to the need to reschedule testing.

Startup services pertaining to instrumentation and control must be under the supervision of the pump control system supplier.

4.2.10.3. Testing.

4.2.10.3.1. **Factory Testing**. Perform testing of each pump on a Hydraulic Institute (HI) compliant test stand in a facility located in one of the contiguous 48 United States. Test each pump in conformance with the latest HI Standards and must include the following:

- Check impeller, motor rating, and electrical connections for compliance with this specification.
- Before testing, run each pump to establish correct rotation.
- Each pump must be run in air.
- Test motor and cable insulation for moisture content for insulation defects.

Furnish a writing quality assurance record for each pump, confirming the above inspections and testing, at the time of the shipment.

Test each pump supplied in conformance with the latest HI Standards at the factory to determine the criteria listed below. Performance curves for the listed criteria must be based on at least seven evenly spaced test points, including shutoff (or as near to it as possible), 1/4, 1/2, 3/4, 4/4, and two additional points. Perform testing points as provided in accordance with HI Test Acceptance Grade 1U; no negative tolerances will be allowed for any tested parameter. At least, provide performance curves for pump and motor speeds of 50%,

75%, 100%, and the two speeds required to meet the design flow and minimum flow listed above. Test each supplied pump for the following criteria:

- Pump head and efficiency versus capacity,
- Motor power, efficiency, and horsepower draw versus capacity, and
- Pump net positive suction head required (NPSHR) vs capacity.

Furnish eight copies of certified performance curves and test reports for each pump before shipment. Report data in Standard English units.

4.2.10.3.2. **Field Testing**. Perform field tests for the purpose of accepting the pumps for mechanical integrity. Submit a proposed test procedure to the Engineer for approval. The Contractor must provide necessary instrumentation.

Perform tests with potable water only. The Contractor is responsible for providing water used in testing.

Tests must first establish that the pump H-Q curves are roughly tracking the factory test curves. At least, five evenly spaced test points must be provided. These must include, while the pump is running at full speed: shutoff, full capacity, ½ capacity and two additional points as directed. Record motor amps and pressure for each point.

After determining that the pumps are performing per the factory H-Q curves, exercise the pump for not less than 1 hr. per pump. Demonstrate that pump, motor, and vibration does not exceed ANSI/HI limits and bearing temperatures do not exceed the manufacturer's recommendations. Vibration testing must be performed by a qualified independent testing agency.

Procure the services of an independent vibration testing agency to measure the vibration and the operating speed of the modified pumping unit under actual operating conditions.

Conduct testing in the presence of the Engineer. Testing must be conducted by a firm or individual whose qualifications are subject to the approval of the Engineer. Testing results must be documented by the Contractor and submitted to the Engineer for approval.

If any equipment fails the vibration tests, replace such equipment or make adjustments until vibration falls within the specified limits. Perform replacement, adjustments, and retesting entirely at no additional cost to the Department.

4.3. **Sludge Pump**. Provide labor, materials, equipment, and services necessary to furnish, install, test, and place in operation a submersible solids handling type pump with explosion proof motor as shown on the plans and specified herein. Orient the units and other physical characteristics as shown on the plans.

Provide sludge pumps of the physical size and weight of the pumps capable of being installed in the wet well, as shown on the plans. There are limitations as to the size and weight of pump that will be able to be installed. No additional compensation will be paid for installation of the pumps. The Contractor will be responsible for any damage that may occur to a pump during installation and will be responsible for repair or replacement to the satisfaction of the Engineer at no additional cost to the Department.

4.3.1. **Shop Drawings**. Only complete submittal packages including mechanical, electrical, structural, controls and instrumentation equipment will be reviewed. Partial submittal packages will be returned to the Contractor without review.

Submit the following required information for pumps, motors and supports.

- **General**:
  - Dimensions
  - Details of construction and installation

- **Motor data**:
  - Manufacturer
  - Model
  - Rated horsepower
  - Efficiency
  - Service factor
  - Current and load data
  - Bearing type
  - Bearing calculations
  - Weight
- **Pump data**:
  - Manufacturer.
  - Model.
    - Certified performance curves with operating points plotted on curves.
    - NPSH curves
- **Rated capacities**:
  - Furnished specialties and accessories.
  - Materials of construction.
  - Pump orientation.
  - Bearing types and lubrication equipment information.
  - Seal types.
  - Weight.
- Pump Start-up and Testing Plan
- Vibration Testing Qualifications
- Operation and Maintenance Manuals:

Submit the following required information for the pumping equipment.

- Equipment function, normal operating characteristics and limiting conditions;
- Assembly, installation, alignment, adjustment and checking instructions;
- Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions;
- Lubrication and maintenance instructions;
- Guide to “troubleshooting;”
- Parts lists and predicted life of parts subject to wear;
- Outline, cross-sections, assembly drawings, engineering data and wiring diagrams; and
- Test data and performance curves

4.3.2. **References**.

- ASTM A48–Standard Specification for Gray Iron Castings
- ASTM A743–Standard Specification for Iron-Chromium Nickel, Corrosion Resistant
- ANSI B16.1–Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125lb.
- HI 14.6–Hydrodynamic Pumps for Hydraulic Performance Acceptance Tests
- HI 11.6–Submersible Pump Tests

4.3.3. **Quality Assurance**. Design and construct the pumps in conformance with standards of the Hydraulic Institute. The efficiency of the pumps, when operating under conditions of the specified capacities and heads, must be as near peak efficiency as practicable.

Obtain pumping equipment, motors, and appurtenances from a single pump supplier whose responsibility it is to ensure that the pumping equipment is properly coordinated and operated in accordance with this Item.

Design and construct mechanical and electrical equipment in conformance with ANSI, HI, and NEMA Standards, latest editions.

Submit shop drawings certified for construction by the pump manufacturer which includes location of electrical connections; wiring diagrams; anchor bolt layout; details indicating construction and materials of construction; diameter of shafting; gear and bearing ratings; installation drawings showing each pump, suction and discharge piping and fittings, specials, supports, concrete pads, clearances, and dimensions to install the pump in the spaces indicated on the plans.

Qualifications: The manufacturer must have 20 or more years of experience and furnished similar equipment for at least five pumping stations.

4.3.4. **Vibration Limits**. The amplitude of vibration of any centrifugal pumping unit, when operating at any of the speeds specified herein must not exceed the requirements set forth in the latest revision of the Hydraulics Institute Standards. The amplitude of vibration for other pumping units must not exceed the requirements of the pump manufacturer's standard.

4.3.5. **Name Plates**. Provide each pump with a stainless-steel nameplate, riveted or bolted to the unit with stainless steel hardware. Nameplates must contain the manufacturer's name, equipment size (i.e., HP, impeller diameter, speed, flow, and head, etc.) and type, serial number, and other pertinent data specified herein.

4.3.6. **Delivery, Storage and Handling**. Preparation for Shipment: Deliver pieces in the largest sizes practical for ease of installation within the existing building and ease of minimal field assembly by the Contractor. Individual pieces must be permanently tagged with welded erection marks or stainless-steel tags cross-referenced with information on the manufacturer's erection and assembly drawings. Field connections must be designed for static, live, and erection loads.

Protect drive units, mechanical, and electrical components from the weather and suitably package to facilitate handling and storage. Provide special lubricating and rust preventative oils to prevent internal corrosion of gear assemblies. Always keep mechanical equipment thoroughly dry and must be stored indoors. Protect equipment stored on the job and maintain in conformance with the manufacturer's recommendations. When requested, provide written certification from manufacturer that the equipment is being properly stored.

Store pumps on site under cover in accordance with this Item.

4.3.7. **Rejected Material and Replacements**. Reject damaged, deteriorated, or contaminated material and immediately remove from the site. Replace rejected materials with new materials at no additional cost.

4.3.8. **Field Services and Warranty**. Provide services of a manufacturer's representative onsite for a minimum of 2 days for installation inspection and field testing for each pump.

The Engineer may elect to rearrange the configuration of the days of site support at his sole discretion. Site visits not used by the manufacturer during the construction period must be made available to the Engineer during the warranty and operations period, not to exceed 2 yr. from the date of conditional acceptance.

Confirm in writing each site visit by a daily log signed by the Engineer and the manufacturer's representative. Failure of the manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit and will not be attributed to the completion of the total specified number of site visits.

Manufacturer's warranty must cover a period of 5 yr., with no hour limitation, non-prorated, from the date of final acceptance. The warranty must cover pumps and motors against defects in materials and workmanship, including parts and factory or authorized service facility labor.

4.3.9. **Spare Parts**. Provide the following spare parts for each pump: Impeller and one of each type of wear ring.

4.3.10. **Products–Sludge Pumps**. Ensure it is possible to lift and lower the pump on parallel guide bars and connect it to the wet well mounted discharge connection. There must be no need for personal to enter the wet well when removing or reinstalling the pumps.

Sealing of the pump unit to the discharge connection must be accomplished by a machined metal to metal watertight contact. Sealing of the pump discharge interface with an O-ring, diaphragm or profile gasket is not acceptable.

The impeller must be a semi-open multi vane self-cleaning impeller designed to transport wastewater with fibrous materials like wet wipes. Impeller must be wear resistant against sand and grit which is expected to enter the pump station with the sewage or storm water.

Performance Requirements:

Flow	376 gpm
Head	45.3 ft
Motor Horsepower (maximum)	7.5 hp
Motor Speed (maximum)	2,917 rpm
Pump Efficiency	68.4%

The NPSHR must be below 10 ft. depth.

The manufacturer must guarantee clog-free operation for a period of 24 mth. from the date of start-up of the pumps by the local authorized factory representative. A certificate must be provided to the Department on the day of start up with the local contact information and effective date. Should the impeller clog with typical solids or modern trash debris normally found in domestic wastewater during this period, an authorized representative must, either travel to the jobsite, remove the pump, clear the obstruction, and reinstall the pump at no cost or reimburse the Department for reasonable cost to provide this service. Provide a written report to the Department detailing the service call with pictures for verification purposes.

Equip the pump with a submersible synchronous electric motor, capable to operate on a 380-480 V, 3 phase, 60 hertz voltage supply. The starting current must not exceed 14 A.

Pump must be capable of handling raw domestic wastewater or stormwater with fibrous materials like wipes.

The impeller blades must be self-cleaning upon each rotation as they pass across a sharp relief groove in the Insert ring that keeps the impeller blades clear of debris. The insert ring must have a guide pin which moves fibers from the center of the impeller to the leading edges of the impeller. The impeller must move axially upwards to allow larger debris to pass through and immediately return to normal operating position. The clearance between the insert ring and the impeller leading edges must be adjustable.

Due to the likely presence of sand and or grit, furnish an impeller and the cutting ring made of ASTM A532 Alloy III A with 25% chrome. Impellers that have surface hardening or coating will not be allowed.

The pump must be capable to operate without any limitation between 50% and 150% of the best efficiency point (B.E.P.) of the performance curve.

The pump, the motor, and the integrated control system must be submersible at least 65 ft. according to IEC 60034 and protection class IP 68. Motors which only can be submerged for a limited time (IP 67) must not be considered as equal.

The motor must be capable to operate the pump at continuous duty (S1) in an ambient temperature up to 104°F. Operational restrictions or the demand of auxiliary cooling systems like fans or blowers are not acceptable. The motor should be non-overloading along the entire pump performance curve.

The pump must be operated by a synchronous motor and an integrated control system and be capable to run at constant power at any point of the performance field without being overloaded. Motor must use a permanent magnet rotor to maintain synchronous speed.

The motor must be capable of withstanding at least 60 starts per hour. Motor must be explosion proof rated.

The discharge flange of the pump must be at least 4 in. and drilled according to ANSI B16.1-89; Table 5.

The impeller must be mounted on the motor shaft. Couplings will not be accepted.

Equip pumps with an integrated pump control system installed in the pump or motor housing which must start the pump by gradually increasing the pump speed. The starting current must not be higher than the rated current.

An integrated pump control system installed in the pump motor housing must secure the correct direction of the impeller rotation. There must be no need for any human intervention to ensure that the impeller is rotating in the correct direction within the volute. The integrated control system must be inside the motor and encapsulated to protect it against moisture ingress and vibration.

The motor and the pump control system must receive enough cooling from the pumped liquid to continuously operate the pump in a liquid at a temperature of 104°F. Operational restrictions on the liquid temperature below 104°F or the demand of auxiliary cooling systems like fans or blowers are not acceptable. The stator must be inverter duty rated in accordance with NEMA MG1, Part 31 and be insulated according to Class H (356°F).

Motor, pump, and control system must be designed and supplied by the pump manufacturer.

The control system must continuously monitor the leakage sensor in the stator housing and the temperature of the motor. It must be impossible to overload the motor. If the motor temperature is too high, the pump must continue to operate at reduced power until conditions are normalized. External trips or overload devices for motor protection must not be required.

The operator must be able to modify the setting of the control system to decide if the active leakage signal must stop or not stop the pump.

The pump must incorporate a “pump-cleaning” function to remove debris from the impeller. The cleaning function must be initiated when the integral control system senses an increase in current draw due to debris in the pump. The cleaning function must consist of forced stopping, reversal, and forward runs timed to allow for debris to fall from the impeller. After the cleaning cycle is complete, the pump must resume to automatic operation. If the pump impeller/volute does not clear itself after the programmed number of attempts, the control must initiate an alarm to notify that the pump inlet or volute is blocked by large debris.

Provide a Human Machine Interface (HMI) making it possible to access and adjust the pump system. The HMI should consist of a unit ranging from basic monochrome displays to full-color touch screen units and smartphone or tablet. It must enable the operator to view and control entire pump system and logged operational data like number of starts, avoided clogging instances, pump run-time, motor power, motor current, power factor, temperature, pump leakage etc.

Provide 15 in. HMI/OIT PCP and Sludge Pump Control Panels manufactured by Harmony GTU, Magelis GTU, or approved equal. Supply the HMI/OIT with necessary HMI software, drives, and other development tools to provide a complete and functional system in conformance with the plans and specifications.

The shaft must rotate on two bearings. The motor bearings must be sealed and permanently grease lubricated with high temperature grease. The upper motor bearing must be a single-row ball bearing to handle radial loads. The lower bearing must be a double-row, angular contact ball bearing to handle the thrust and radial forces. Single row lower bearings are not acceptable. The L10 bearing life must be at least 50,000 hours at any usable portion of the pump performance field.

The shaft must be sealed by a tandem mechanical shaft seal system consisting of two seals, each with an independent spring system. The seals must require neither maintenance nor adjustment and must be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal function.

Where a seal cavity is present in the seal chamber, the area about the exterior of the lower mechanical seal in the cast iron housing must have cast in an integral concentric spiral groove. This groove must protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

Provide the following materials of construction:

- **Pump housing**: ASTM A-48, Class 35B
- **Impeller and insert ring**: A 532 ALLOY III A (25% chrome)
- **Stator housing**: GD-AL SI 12 or ASTM B85A 413
- **Shaft**: ASTM A479 S43100-T
- **Shaft seal**: Pump side: Corrosion resistant Tungsten carbide (WCCR)
- **Shaft seal motor side**: Corrosion resistant Tungsten carbide (WCCR)

Blast castings before coating. Coat wet surfaces with two-pack oxirane ester Duasolid 50. The total layer thickness must be at least 120 microns. Zinc dust primer must not be used.

Equip the motor with screened cable S3x6+3x6/3+S(4x0,5) suitable for submersible pump applications. Coordinate cable length with field installation requirements. Size the power cable according to NEC and ICEA standards. The outer jacket of the cable must be oil resistant chlorinated polyethylene rubber. The cable must be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 ft.

Supply each pump with a mating cast iron discharge connection. The pumps must be automatically and firmly connected to the discharge connection, guided by at least two stainless steel guide bars extending from the top of the station to the discharge connection to ensure pump stability when installing or removing the machine. There must be no need for personnel to enter the wet well to access the pump. Seal the pumping unit to the discharge connection by a machined metal to metal watertight contact. Sealing off the discharge interface with a diaphragm, O-ring or profile gasket will not be acceptable. No portion of the pump can bear directly on the wet well floor.

The guide rail system must consist of two parallel 2-in. guide bars, supported by pump manufacturer supplied upper guide rail brackets. Guide bars and guide brackets must be Type 304 stainless steel.

Fit each pump with stainless steel lifting cable. Connect the lifting cable to the lifting handle of the pump and be long enough to reach the top elevation of the station. Lifting chain must be compatible with the Grip-Eye Pump Lift System. The working load of the lifting system must be 50% greater than the pump unit weight.

Provide one pump lift system Grip-Eye for each pump. The Grip-Eye must allow for utilizing a hoist for lifting each pump from its installed position to above the top elevation of the station. Configure the Grip-Eye device

to slide down the stainless-steel lifting chain and grip the lifting chain near pump handle. Appropriately size the retrieval system for the weight of the pump to be lifted.

Supply submersible cable connection boxes meeting the requirements of NEMA 6P. Connect the submersible cable of the pump to the wall mounted power & monitoring cables in a cable connection box to ease the installation and disassembling of the pumps. The cable connection box must be submersible NEMA 6P (IP 67) to ensure that no water can enter the motor via the cables even when the station is flooded.

Sump Pump Discharge Line. Provide the following components:

- **Discharge Pipe and Fittings**. Provide flanged ductile iron, Class 54 pipe with Protecto 401 ceramic epoxy lining. Provide Class 125 flanges and coordinate flanges with the connecting equipment. Where flange adapters are necessary, use EBAA Iron Megaflange 2100 or equivalent from Star Pipe Products. Provide fittings and pipe from the same manufacturer. Provide 1/8 in. thick, AWWA C207 gaskets. Test piping in accordance with AWWA C600 to 1-1/2 times the working pressure, but not less than 150 psi.
- **Provide protective pipe coatings suitable for immersion service**. Prepare surfaces per the manufacturer's requirements. Provide one coat of Series V69 Hi-build Epoxoline II at 3-4 mils dry film thickness (DFT) and two coats of Series 435 Perma-glaze at 7-9 DFT per coat as manufactured by Tnemec or equivalent system, and one coat of Phenoline 311 at 2-3 mils DFT and one coat Plastie 4500S at 45-55mils DFT as provided by Carboline, or approved equal. Provide color chart for Department selection.
- **Bolts**. Provide stainless steel bolts and nuts for flanged piping, fittings, and couplings.
- **Pipe Coupling**. Provide restrained coupling as manufactured by Smith Blair, Romac, Dresser, Rockwell, or equal. Provide high strength stainless steel nuts and bolts.
- **Check Valve**. Provide iron body, sinking ball type check valve, flanged, suitable for vertical installation with exterior coating per manufacturer standard coating. Design of valve should be non-clogging and self-cleaning. Valve should be resilient seated and provide full port flow path. Provide ductile iron bonnet, stainless steel bolts, and aluminum core ball vulcanized with rubber on the sides. Provide valve from VAG Group, G.A. Industries, or approved equal.

4.3.11. **Execution**.

4.3.11.1. **Installation**. Install the pumping systems in complete compliance with applicable requirements of the latest edition of ANSI/HI and the manufacturer's recommendations. Remove existing sump pumps from operation before initiating activities within an area. Install and maintain temporary sump pumps for the duration of construction activities within an area.

4.3.11.2. **Startup Services and Training**. Furnish the service of a qualified, factory-trained service representative who must inspect the complete equipment installation under the supervision of the pump control system supplier to ensure that it is installed in conformance with the manufacturer's recommendations, make any adjustments necessary to place the system in trouble-free operation, and instruct the operating personnel in the proper maintenance and operation of the equipment furnished.

The Department reserves the right to videotape and archive start-up and training instruction provided by the manufacturer or authorized representative.

After the pumps are completely installed and wired, the manufacturer's service representative must perform the following:

- Megger stator and power cables;
- Check seal lubrication;
- Check for proper rotation;
- Check power supply voltage;

- Measure motor operating load and no-load current;
- Check level control operation and sequence; and
- Make adjustments, as necessary.

Furnish a written start-up report providing measurements and readings, confirming checks and inspections, indicating the adjustments made, and certifying that the installation and operation complies with the specifications and the pump manufacturer's recommendations. The manufacturer's representative must provide the tools and test equipment required to perform testing. Should the manufacturer's representative fail to provide the necessary testing equipment, the start-up will be rescheduled at the Contractor's expense. The Contractor will not be entitled to additional time or money due to the need to reschedule testing.

Start-up services pertaining to instrumentation and control performed under the supervision of the pump control system supplier.

4.3.12. **Testing**.

4.3.12.1. **Factory Testing**. Test each pump on a Hydraulic Institute (HI) compliant test stand in a facility located in one of the contiguous 48 United States. Test each pump in conformance with the latest HI Standards and must include the following.

- Check impeller, motor rating, and electrical connections for compliance with this Specification.
- Before testing, run each pump to establish correct rotation.
- Each pump must be run in air.
- Test motor and cable insulation for moisture content for insulation defects.

Furnish a writing quality assurance record for each pump, confirming the above inspections and testing, at the time of the shipment.

Test each supplied pump in conformance with the latest HI Standards at the factory to determine the criteria listed below. Performance curves for the listed criteria must be based on at least 7 evenly spaced test points, including shutoff (or as near to it as possible), 1/4, 1/2, 3/4, 4/4, and two additional points. Perform testing points in accordance with HI Test Acceptance Grade 1U; no negative tolerances will be allowed for any tested parameter. At least, performance curves must be provided for pump and motor speeds of 50%, 75%, 100%, and the 2 speeds required to meet the design flow and minimum flow listed above. The following criteria must be tested for each supplied pump.

- Pump head and efficiency versus capacity.
- Motor power, efficiency, and horsepower draw versus capacity.
- Pump Net Positive Suction Head Required (NPSHR) vs capacity.

Furnish eight copies of certified performance curves and test reports for each pump before shipment. Report data in Standard English units.

4.3.12.2. **Field Testing**. Run field tests for the purpose of accepting the pumps for mechanical integrity. Submit a proposed test procedure to the Engineer for approval. Provide the necessary instrumentation.

Perform tests with potable water only. The Contractor is responsible for providing water for any testing.

Tests must first establish that the pump H-Q curves are roughly tracking the factory test curves. At least, five evenly spaced test points must be provided. These must include, while the pump is running at full speed: shutoff, full capacity, 1/2 capacity and two additional points as directed. Record motor amps and pressure for each point.

After determining that the pumps are performing per the factory H-Q curves, exercise the pumps for not less than 1 hr. per pump. Demonstrate that the pump, motor, and vibration do not exceed ANSI/HI limits and

bearing temperatures do not exceed the manufacturer's recommendations. Vibration testing must be performed by a qualified independent testing agency.

Procure the services of an independent vibration testing agency to measure the vibration and the operating speed of the modified pumping unit under actual operating conditions.

Testing Agency Qualifications: Conduct testing in the presence of the Engineer. Testing must be conducted by a firm or individual whose qualifications are subject to the approval of the Engineer. Document testing results and submit to the Engineer for approval.

If any equipment fails the vibration tests, replace or adjust such until vibration falls within the specified limits. Replacement, adjustments, and retesting must be performed entirely at Contractor's expense.

4.4. **Flap Gate**. The Contractor must furnish labor, materials, and equipment required for installation of flap valves.

4.4.1. **Quality Assurance**. The manufacturer must have at least 10 yr. experience manufacturing flap valves and must show evidence of satisfactory operation in at least 5 installations. The company must be ISO 9001 certified.

Flap gates, wall thimbles, and related equipment must be designed, manufactured, and installed in conformance with the best practices and methods, and must operate satisfactorily when installed as shown on the plans.

Provide flap gates from a single manufacturer.

Furnish new and unused equipment that are standard products of manufacturers with a successful record of manufacturing and servicing the equipment and systems specified herein.

Manufacturer's Representative Services. Provide a factory representative who has complete knowledge of proper operation and maintenance for at least one 8-hr. day (exclusive of travel time) to instruct representatives of the Department on the proper operation and maintenance of the equipment. If there are difficulties in operation of the equipment due to the manufacturer's fabrication or the Contractor's installation, additional service must be provided at no change in Contract price or time.

4.4.2. **Submittals**. The manufacturer must submit plans showing critical dimensions, general construction, and materials used in the valve. Submittals must include the following.

- Complete description of materials.
- Certified shop and installation drawings showing details of construction, dimensions, and anchor bolt locations and sizes.
- Descriptive bulletins, and catalogs of the equipment.
- Complete bill of materials.
- A list of manufacturer's recommended spare parts with the manufacturer's current price for each item. Include gaskets, packing, etc. on the list. List bearings by bearing manufacturer's numbers only.
- Design calculations for the gate. Calculations must identify loading conditions, anchorage, and must verify that stresses and deformations will not impair operation and are within specification requirements. These calculations must be stamped by a Professional Engineer Licensed in the state of installation.

Operation and maintenance instructions. Provide a list of manufacturer's recommended set of spare parts and prices required for normal operation and maintenance.

Submit the following test reports.

- Description of test procedures and equipment.

- Copies of test results.

4.4.3. **Field Services and Warranty**. Provide services of manufacturer's representative onsite for installation inspection and field testing. Provide for the above services to be performed during separate visits to the project site. Notification of coordinating the site visits must be provided to the Engineer in writing at least 14 days before each site visit. The engineer reserves the right to reschedule each of the site visits with a 7-day period.

Each site visit must be confirmed in writing by a daily log signed by the Engineer and the manufacturer's representative. Failure of the manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit made and will not be attributed to the completion of the total specified number of site visits.

After each installation, inspection, field testing, and start-up trip a written report covering the representative's findings must be submitted. Report must include inspection findings, field test results, installation approval, any deficiencies noted, and remedies for the deficiencies. Trip reports must be submitted within 3 days followinbg the field service.

The manufacturer must warrant equipment manufactured by it to be free from defects in workmanship or material for a period of 2 yr. from date of conditional acceptance. If during said warranty period, any components prove to be defective in workmanship or material under normal use and service they will be replaced or repaired free of charge, inclusive of freight and labor.

4.4.4. **Delivery, Storage, and Handling**. Properly store and protect parts so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units are ready for operation. Properly protect equipment and parts against any damage during a prolonged period at the site. Factory assembled parts and components must not be dismantled for shipment unless permission is received in writing from the Engineer. Properly protect finished iron or steel surfaces not painted o prevent rust and corrosion. Do not ship equipment until approved in writing.

4.4.5. **Products**.

4.4.5.1. General Design for Flap Gate.

- Flap gates must open when there is a differential pressure across the flap of 6 in. or less.
- Flap gates must be substantially watertight under design load head conditions.
- Under the design seating head, the leakage must not exceed 0.10 US gpm per ft. of seating perimeter.
- Flap valve must have a cast iron body and cover.
- Seat and disc ring must be bronze, and the hinge pin and cotter pins must be stainless steel.
- Valve must be constructed with a 10-degree offset from vertical to ensure positive closure.
- The flange must be drilled using an ANSI 125# template.
- All iron parts must be coated in TNEMEC 2-part epoxy with 3-4 mils dry film thickness to prevent rusting or corrosion.
- The valve must be machined, assembled, and tested in the USA for quality assurance.
- The manufacturer must show proof of ISO 9001 certification.
- Valve and accessories must be manufactured by Troy Valve, Model A2540, Kenedy or approved equal. Flap gate basis of design is Troy Valve. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the Contractor with no extra cost to the Department.

4.4.5.2. **Factory Inspection and Testing**. Perform factory inspection, testing, and correction of deficiencies in conformance with the referenced standards and as noted herein.

4.4.6. **Execution**.

4.4.6.1. General.

- Install appurtenances per the manufacturer's instructions in the locations shown, true to alignment and rigidly supported. Repair any damage to the above items to the satisfaction of the Engineer before installing.
- Assume responsibility for the proper location of gates and appurtenances during the construction of the work.
- Carefully inspect materials for defects in construction and materials. Clean out debris and foreign material out of openings, etc. Check operating mechanisms for proper functioning and check nuts and bolts for tightness. Repair or replace equipment which does not operate easily, or is otherwise defective, at no additional cost to the Department.
- Where installation is covered by a referenced standard, perform installation in conformance with that standard, except as herein modified, and the Contractor must certify such. Also note additional requirements in other parts of this Item.
- Unless otherwise noted, make up joints for gates and appurtenances using the same procedures as specified under the applicable type connecting pipe joint and install gates and other items in the proper position as recommended by the manufacturer. Assume responsibility for verifying manufacturers' torquing requirements for the gates.

4.4.6.2. **Inspection, Testing, and Correction of Deficiencies**. Before plant start-up, inspect items for proper alignment, quiet operation, proper connection, and satisfactory performance.

4.4.6.3. **Cleaning**. Inspect items including gate interiors before line closure, for the presence of debris.

4.5. **Ductless Split System Heat Pumps**. Provide split-system heat-pump unit consisting of separate evaporator-fan and compressor-condenser components. The split system heat pump must be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. The equipment must be constructed to the following standards.

4.5.1. **Action Submittals**. Submit the following for each type of product indicated.

- Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - Refrigeration piping system sizing and field configuration based upon actual equipment location and manufacturers specific requirements.
- Informational Submittals. Submit a sample of the special warranty.
- Closeout Submittals. Submit a copy of operational and maintenance data.

4.5.2. **Quality Assurance**.

- Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- ASHRAE Compliance:
- Fabricate and label refrigeration system to comply with ASHRAE 15, “Safety Standard for Refrigeration Systems.”
- ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4-“Outdoor Air Quality,” Section 5-“Systems and Equipment,” Section 6-“Procedures,” and Section 7-“Construction and System Start-up.”
- ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

4.5.3. **Special Warranty**. Provide manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period. The warranty should cover the following periods:

- **For Compressor**: Manufacturers extended warranty for 5 yr. from date of Substantial Completion.
- **For Parts**: 2 yr. from date of Substantial Completion.
- **For Labor**: 2 yr. from date of Substantial Completion.

4.5.4. **Wall-Mounted**, **Evaporator-Fan Components**.

- **Cabinet**: Enameled steel with removable panels on front and ends in color as shown in plans, and discharge drain pans with drain connection.
- **Refrigerant Coil**: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
  - Fan: Direct drive, centrifugal.
  - Fan Motors:
- Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 “Common Motor Requirements for HVAC Equipment.”
  - Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
  - Retain first subparagraph below if enclosure is not open-drip proof type. Retain second subparagraph for premium efficiency.
  - Enclosure Type: Totally enclosed, fan cooled.
  - NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
- **Controllers, Electrical Devices, and Wiring**: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - Mount unit-mounted disconnect switches on exterior of unit.
- If unique characteristics are required for motors in this Section, insert subparagraphs below.
- **Condensate Drain Pans**:
  - Fabricated with 1% slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
  - Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
- **Drain Connection**: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
  - Minimum Connection Size: NPS 1.
- **General Requirements for Air Filtration Section**:
- Comply with NFPA 90A.
- Minimum MERV according to ASHRAE 52.2.
  - Filter-Holding Frames: Arranged for flat orientation, with access doors on both sides of unit. Filters must be removable from one side or lifted out from access plenum.
- **Air-Cooled, Compressor-Condenser Components**:
  - Casing: Steel, finished with baked enamel in color selected by Engineer, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
  - Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor must have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    - Compressor Type: Scroll.
    - Refrigerant: R-410A.

- **Refrigerant Coil**: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
- **Heat-Pump Components**: Reversing valve and low-temperature-air cutoff thermostat.
- **Fan**: Aluminum-propeller type, directly connected to motor.
- **Motor**: Permanently lubricated, with integral thermal-overload protection.
- **Mounting Base**: Polyethylene.
- **Accessories**:
  - Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
  - Compressor time delay.
  - 24-hour time control of system stop and start.
- Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
- **Fan-speed selection including auto setting**.
  - Automatic-reset timer to prevent rapid cycling of compressor.
- **Refrigerant Line Kits**: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

4.5.5. **Execution**.

- **Installation and Demonstration**. Install the split system heat pump level and plumb. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure. Install ground-mounted, compressor-condenser components on polyethylene mounting base.

  Field Quality Control. Perform tests and inspections. Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- **Tests and Inspections**:
  - Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- **Test and adjust controls and safeties**. Replace damaged and malfunctioning controls and equipment.
  - Prepare test and inspection reports.
- **Demonstration**. Train Department's maintenance personnel to adjust, operate, and maintain units.

4.6. **Sidewall Propeller Fans**. Provide wall-mounted propeller fan meeting the following requirements.

4.6.1. **Action Submittals**.

- **Product Data**: Provide the following for each type of product.
  - Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
- Rated capacities, operating characteristics, and furnished specialties and accessories.
- Certified fan performance curves with system operating conditions indicated.
  - Certified fan sound-power ratings.
  - Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - Material thickness and finishes, including color charts.
- Dampers, including housings, linkages, and operators.
- **Shop Drawings**:
  - Include plans, elevations, sections, and attachment details.

- Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - Include diagrams for power, signal, and control wiring.
  - Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

4.6.2. **Informational Submittals**.

- **Coordination Drawings**: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.
- **Seismic Qualification Data**: For fans, accessories, and components, from manufacturer.
- **Basis for Certification**: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- **Dimensioned Outline Drawings of Equipment Unit**: Identify center of gravity and locate and describe mounting and anchorage provisions. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- Field quality-control reports.

4.6.3. **Closeout Submittals**. For centrifugal fans to include in normal operation, provide emergency operation, and maintenance manuals with replacement parts listing.

4.6.4. **Maintenance Material Submittals**. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

4.6.5. **Products**.

General.

- **Housing**: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
- **Fan Wheels**: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.
- **Belt Drives**:
  - Resiliently mounted to housing.
  - Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
  - Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
- **Accessories**:
- **Bird Screens**: Removable, 1/2-in. mesh, aluminum or brass wire.
  - Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
  - Spark-resistant, all-aluminum wheel construction.

4.6.6. **Installation and Demonstration**.

- Wall-mounted propeller fans must be installed using the following criteria:
  - Install power ventilators level and plumb.
  - Install units with clearances for service and maintenance.
  - Label units according to requirements specified in this Item.
- Engage a factory-authorized service representative to perform start-up service.
- Complete installation and start-up checks in conformance with manufacturer's written instructions.

- Verify that shipping, blocking, and bracing are removed.
- Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
- Verify that cleaning and adjusting are complete.
- For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
- Adjust belt tension.
- Adjust damper linkages for proper damper operation.
- Verify lubrication for bearings and other moving parts.
- Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
- Disable automatic temperature-control operators, energize motor, and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
- Shut unit down and reconnect automatic temperature-control operators.
- Remove and replace malfunctioning units and retest as specified above.
- Train Department's maintenance personnel to adjust, operate, and maintain centrifugal fans.

4.7. **Fixed Louvers**. Provide wall-mounted louver meeting the following requirements.

4.7.1. **Action Submittals**.

4.7.1.1. **Product Data**: For each type of product, provide the following:

- Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
- Rated capacities, operating characteristics, and furnished specialties and accessories.
  - Material thickness and finishes, including color charts.

4.7.1.2. **Informational Submittals**. Provide sample of special warranty.

4.7.1.3. **Closeout Submittals**. Provide operation and maintenance data.

4.7.2. **Products–Louvers**. Provide fixed extruded aluminum louvers.

Horizontal, Continuous-Line, Drainable-Blade Louver, Extruded Aluminum: Drainable-blade louver with blade gutters (drains) in rear two-thirds of blades only.

- Louver depth: 6 in.
- Frame and Blade Nominal Thickness: Not less than 0.080 in. (2.03 mm).
- Mullion Type: Semi-recessed.
- Louver Performance Ratings:
- Free Area: Not less than 7.8 sq. ft. for 48-in. wide by 48-in. high louver.
- Point of Beginning Water Penetration: Not less than 850 fpm.
- Air Performance: Not more than 0.10-in. wg static pressure drop at 800-fpm free-area intake velocity.
- AMCA Seal: Mark units with AMCA Certified Ratings Seal.
- Finish: As selected by architect from manufacturer’s full range.

4.7.3. **Execution**.

4.7.3.1. **Examination**. Examine substrates and openings, with Installer present, for compliance with requirements for

installation tolerances and other conditions affecting performance of the Work. Proceed with installation only after unsatisfactory conditions have been corrected.

4.7.3.2. **Preparation**. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

4.7.3.3. **Installation**. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

Form closely fitted joints with exposed connections accurately located and secured.

Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with joint for sealants applied during louver installation as indicated on the plans and this specification.

4.7.3.4. **Adjusting and Cleaning**. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

4.8. **General Electrical Provisions**.

4.8.1. **General**. Perform electrical work in conformance with the applicable codes, standards, and ordinances including, but not limited to, National Fire Protection Association (NFPA), International Building Code (IBC), Underwriter's Laboratory (UL).

Employ a master electrician, licensed in the State of Texas to directly supervise the Contractor forces.

Provide electrical submittals that are certified correct by the master electrician. Ensure persons performing electrical work have an appropriate electrical license.

Provide documentation that proves the Contractor has at least 5 yr. of experience and is qualified in this type of scope and work.

Install electrical service as shown on the plans and as required by the electrical utility company. Provide temporary electrical equipment, materials, and service necessary for constructing the pumping station, including any for dewatering.

Provide electricians to make necessary connections of the portable load banks to the load lugs of the generator or generator main breaker for the required generator set testing.

The Electrical Contractor must provide labor, materials, equipment, and services for a complete electrical system required for this contract including, but not limited to:

- Coordination of connections and providing conduits for work required for the electrical service.
- Electrical equipment and building grounding systems.
- Electrical connections complete to equipment whether indicated on the plans or not.
- Motor starters and disconnects as required by the National Electrical Code. Provide power wiring from panel to disconnect or starter and to motor or equipment. Wire line voltage controls carrying motor or equipment power.
- Support systems for electrical work.
- Cutting and patching as required for electrical work.
- Temporary electrical service if required during construction.
- Testing of electrical systems.
- Coordinate work with Control System Supplier and provide related conduit and wiring for power and controls.
- Motor Control Center, automatic transfer switches, transformers, and required distribution equipment and associated feeders, and standby power system.
- Station lighting systems.
- All pump power, control, and alarm wiring.
- All wiring, conduit, and other equipment, whether shown on the plans or specifically mentioned in the specifications or not, to accomplish a fully functional electrical system.

4.8.2. **Submittals**. All submittals must include enough data to make a thorough evaluation of features, construction, and performance.

Materials, equipment, and fixtures must completely satisfy specification requirements and be suitable for their intended use. Items of equipment submitted must include accessories and options recommended by the manufacturer for satisfactory, reliable, and safe operation in its designated location.

Manufacturer's model and catalog numbers change frequently and may not necessarily include specified or required features and may not ensure compatibility with supporting systems or intended application. Ensure that material and equipment delivered to the jobsite is suitable for the intended application and indicated connections. Review of shop drawings must not include review and verification of submitted catalog numbers or quantities required.

Ship or fabricate equipment in sections of suitable size for entering building and necessary arrangements for their installation must be made by the Contractor.

Shop drawings and submittals must bear the General Contractor's review and approval stamp before submission to the Engineer.

Submit copies of shop drawings for electrical equipment custom made for this contract. Drawings must be revised as directed and resubmitted.

Submittals must show physical size and arrangement of equipment, wiring diagrams for equipment showing circuit devices, and elementary control diagrams in straight-line form for motor control equipment.

Cleary indicate in submittals which products are to be provided as part of this project.

Submit conduit layout proposed for the project for review and approval before installation.

4.8.3. **Materials**. Supply new materials listed by the Underwriters Laboratories, Inc., or locally approved national testing agency as conforming to standards in every case where such a standard has been established for a particular material in question. Equipment must be packaged in their original containers.

Furnish equipment or materials for any one system by the same manufacturer. Such items include conduit, wire, motor control center, wiring devices, etc.

Materials installed on exterior of buildings must be weathertight and of such design as intended for this purpose.

Install equipment in strict conformance with manufacturer's instructions for type, capacity, and suitability of each piece of equipment used. Install equipment in conformance with manufacturer's recommendations and meet conditions of manufacturer's standard warranty.

Protect work, materials, or equipment which are liable to cause injury during construction period. Securely cover or otherwise protect openings into any part of conduit system as well as associated fixtures, equipment, both before and after being set in place to prevent obstruction of conduit or injury due to carelessness or maliciously dropped tools or materials, grit, dirt, or any foreign matter. Contractor is responsible for damage so done until his work is installed and accepted. Cover conduit ends with capped bushings.

Furnish reinforced concrete housekeeping pads, at least 4 in. thick or as noted, and extending 6 in. beyond equipment for free-standing electrical distribution equipment, or as noted on the plans.

Provide accessories, equipment and connections required for complete installation, ready for continuous use.

Perform NETA Acceptance tests on each piece of equipment installed for this project. Tests labeled as optional are not required to be performed. Give timely notice of intention to test work to permit observation. Obtain the services of an independent NETA Member Testing Agency to perform any testing. The Testing Agency must test the entire electrical system in conformance with current procedures stated in Acceptance Testing Specifications published by the National Electric Testing Association. Furnish equipment necessary to conduct such test at the Contractor's expense.

4.8.4. **Coordination with Other Trades**. Confer with other trades whose work might affect installation and arrange work in proper relation to that of others.

Where interferences occur, Contractor must, before installing work involved, consult with the engineer and other trades to reach agreement as to exact location and level of work, and submit agreed upon layout for approval before starting this work.

Contractor is responsible for arrangement of work, equipment, and maintenance of proper clearances for installation. Should work installed require modification to avoid interference, such changes must be made without additional cost.

If work is dependent for its proper execution on contiguous work not specified, examine such work and report in writing any defects therein or conditions rendering it unsuitable. Beginning of work without making of such a report must constitute an acceptance of work, and any subsequent defects in his work consequent must be the Contractor's responsibility.

4.8.5. **Permits**. Obtain permits, licenses or pay fees not otherwise identified under provisions of General Conditions of this contract specification.

4.8.6. **Guarantee**. Unless otherwise specified, unconditionally guarantee for a period set forth in the General Conditions, but not less than 2 yr., materials, workmanship, and installation. During this period, adjust, repair, or replace at no cost to the Department any item of equipment or workmanship found to be defective. Contractor will be responsible for and pay for damages cause by or resulting from defects in workmanship.

4.9. **Electrical Testing.**

4.9.1. **Submittals**.

Qualification Data: For testing agency, submit company profile, listing of 10 similar projects performed in the last 2 yr. including contact information as references, and company and employee qualifications and certifications.

Final Equipment Test Report: After specified field inspection, testing and evaluation are completed, submit for approval the final equipment test report. Each equipment test report must be clearly labeled with whether the equipment passed or failed the test.

Project Work Schedule. Coordinate project work schedule with the Engineer and submit for approval before start of work.

4.9.2. **Quality Assurance**.

The testing agency must be a single independent agency, with the experience and capability to conduct the required inspections and testing indicated that is a current full member company of the International Electrical Testing Association (NETA), and that is acceptable to the Authorities Having Jurisdiction (AHJ). Companies that are not a current full member company of NETA will not be permitted to bid on or perform this work. Persons performing inspection and testing functions must be permanently employed by the single independent agency. The testing agency's field supervisor must be a person currently certified by NETA to supervise onsite testing specified in these specifications.

The testing agency must have an up-to-date equipment calibration program. All test equipment used must be currently calibrated. Submit certifications of calibration for all equipment.

Before submitting the bid, the Contractor must visit the site and be thoroughly familiar with the existing conditions. Any errors, discrepancies, or missed items must be brought to the attention of the Engineer during the bidding process. No additional cost will be allowed for any discrepancy that could have been noticed at the site visit by the Contractor.

4.9.3. **Project Conditions**. This work will be performed in an existing operational facility. Perform work in conformance with the Department's schedule requirements to provide minimal impact to the building operations.

4.9.4. **Execution**. Inspection and Electrical Testing. Perform visual and mechanical inspections and electrical tests in conformance with applicable sections of the latest edition of the NETA Acceptance Testing Specifications (ATS) and in conformance with manufacturer recommendations for electrical equipment that is installed as part of this project. Optional tests referred to in the NETA ATS are not required. Return equipment to safe operational condition after inspections and electrical tests are completed.

Final Equipment Test Report. Prepare and submit for approval a written Final Equipment Test Report including the results from inspections, electrical testing, and power system data collection. The report must include, but not be limited to the items listed below. Submittals received without the information listed below will be rejected in their entirety and will not be reviewed:

- **Cover Sheet**: Typed, including project name, project location, testing agency name, and date.
- **Summary of results**: Typed, summarizing inspection results, test results and recommendations for any required corrective actions. Note: all equipment must be evaluated. All equipment must be noted as being acceptable or requiring corrective action (with recommended corrective action noted).
- Letter from the testing agency stating that equipment included in the report has been tested and evaluated in conformance with applicable NETA recommendations.

- Equipment inspection and test data sheets including the following: Date of Test, Equipment designation, field inspection and test data including NETA required information, Clear Pass/Fail indication on each sheet for each piece of equipment, recommended corrective action for any discrepancies, deficiencies or other as-found conditions requiring repair.

4.10. **Overcurrent Protective Devices Coordination and Arc Flash Study**. This Section includes computer-based, fault-current and overcurrent protective device studies, and the setting of these devices. This Section also includes completion of an arc flash study. The studies and reports must include the electrical system from the utility company service entrance down to and including proposed and existing to remain MCC's, panelboards, motors, automatic transfer switches, disconnect switches, generators, and any other major distribution system equipment. The studies and reports must address possible system switching configurations and alternate operating conditions that could result in maximum fault current conditions or worst-case incident energy levels.

4.10.1. **Submittals**.

- **Product Data**: For computer software program to be used for studies
- **Qualification Data**: For coordination Study Specialists
- **Action Submittals**:
- Coordination-study input data, including documentation from the utility company stating the available fault current at the service entrance.
  - Coordination-study report
  - Short Circuit evaluation report for equipment.
  - Settings report for adjustable trip devices.
  - Arc Flash study report.
  - Arc Flash warning labels for use in the field.

4.10.2. **Quality Assurance**. Studies must use computer programs that are distributed nationally and are in wide use. Software algorithms must comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

Coordination-Study Specialist Qualifications. An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices for at least 3 yr. Submitted study must be stamped and signed by a professional engineer licensed in the state of Texas.

Comply with IEEE 399 for general study procedures. Comply with IEEE for short-circuit currents and coordination time intervals.

4.10.3. **Products**. Perform the studies using one of the following software packages: SKM or ETAP.

4.10.4. **Execution**.

4.10.4.1. **Examination**. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Proceed with coordination study only after relevant equipment submittals have been assembled. Do not use in the study overcurrent protective devices not submitted for approval with coordination study. Studies must be based on equipment approved for use on this project. Perform site survey to obtain any additional information that is not shown on the plans required to complete the specified studies. Coordinate with the local utility for site specific available fault-current data.

4.10.4.2. Fault-Current Study.

- **Source Impedance**: Utility Company's fault-current contribution. Coordinate with the local utility for site specific fault current data.

- Study electrical distribution system from normal and alternate power source throughout electrical distribution system for project and use approved computer program to Eq values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions. Study and report must include the electrical system from the utility company service entrance down to and including MCC's, panelboards, motors, automatic transfer switches, disconnect switches, generator, and any other major distribution system equipment.
- Calculate momentary and interrupting duties on the basis of maximum available fault current.
- Calculations to verify interrupting ratings of overcurrent protective devices must comply with the following.
  - Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50
  - Low-Voltage Fuses: IEEE C37.46
  - Circuit Breakers: IEEEC37.13
  - Other Equipment: As Applicable
- Study Report: Enter calculated X/R ratios and interrupting fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2 Cycle), interrupting, and 30-cycle fault-current values for 3-phase, 2-phase, and phase to ground faults.
- **Equipment Evaluation Report**: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault current momentary and interrupting duties.

4.10.4.3. **Coordination Study**. Gather and tabulate the following input data to support coordination study:

- Product data for overcurrent protective devices. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
- Impedance of utility service entrance
- Circuit breaker and fuse current ratings and types
- Transformer kVA, primary and secondary voltages, connection type, impedance, and X/R ratio
- Cables including conduit material, sizes of conductors, conductor material, conductor insulation, and length.
- Motor horsepower and code letter designation according to NEMA MG 1.
- Data sheets to supplement electrical distribution system diagram, cross referenced with tag numbers on diagram.

Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399. Provide recommended settings for adjustable overcurrent protective devices including, but not limited to the generator. Provide time current curve for the devices.

Comply with NFPA 70 for overcurrent protection of circuit elements and devices. Comply with IEEE 141 and IEEE 242 recommendations for fault currents and time intervals.

Transformer Primary Overcurrent Protective Devices: Devices must not operate in response to full load current or permissible transformer overloads in accordance with IEEE C57.96.

Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

Prepare a report indicating the following results of the coordination study:

- Tabular format of settings selected for overcurrent protective devices including device tag, relay current transformer ratio, circuit breaker sensor rating, long time, short time and instantaneous settings, and ground fault relay pickup and time delay settings.
- **Coordination curves**: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Curves must show device tag, voltage, and current ratio for curves, three phase and single-phase damage points for transformers, cable damage curves, transformer inrush points, maximum fault current cutoff point.
- Completed data sheet for setting overcurrent devices.

4.10.4.4. **Overcurrent Protective Device Setting**. Engage a qualified testing agency to perform the device setting and to prepare test reports. After installing overcurrent protective devices and during energizing process of electrical distribution system, verify that the overcurrent protective devices meet parameters used in studies. Adjust devices to values listed in study results.

4.10.4.5. **Arc Flash Study**. Perform an arc flash study in conjunction with the previous specified fault current and protective device coordination study. Perform study in accordance with IEEE 1584.

The study must be calculated using an approved computer software program. Pertinent data and the rational employed in developing the calculations must be incorporated into the introductory remarks of the study. The study must include the electrical system from the utility company service entrance down to and including MCCs, panelboards, motors, automatic transfer switches, disconnect switches, enclosed circuit breakers, generator, and other major distribution equipment.

Determine the following for each bus analyzed:

- Flash Hazard Protection Boundary
- Incident Energy Level
- Required Personal Protective Equipment (PPE) Category
- Type of Fire Rated Clothing
- Limited Approach Boundary
- Restricted Approach Boundary
- Prohibited Approach Boundary

Produce an Arch Flash warning label for each piece of electrical equipment that includes a specific equipment ID. Also include the system operating voltage and date of study. Labels must be printed in color on adhesive backed nylon labels. Sample label must be submitted for approval before installation. Labels must follow lates NFPA requirements.

Prepare a written report indicating the following results in tabular format:

- Flash Bus Name
- Protective Device Name
- Bus Operating Voltage
- Bus bolted fault current.
- Protective device bolted fault current
- Protective device arcing fault current
- Trip/delay time
- Breaker opening time
- Ground
- Equipment type
- Gap (mm)
- Arc Flash Boundary (in.)

- Working Distance (in.)
- Incident energy (cal/sq.cm)
- Required Personal Protective Equipment

The electrical Contractor must permanently affix the arc flash warning labels to each piece of electrical equipment including, but not limited to, motor control centers, panelboards, automatic transfer switches, disconnect switches, enclosed circuit breakers, and any other major distribution system equipment.

4.11. **Electric Materials and Methods.**

4.11.1. **Products**.

- **Raceways and Fittings**. For underground conduit, use PVC Schedule 80, heavy wall, UL listed. Provide at least 3 in. of clearance between conduits and at least 24 in. of cover or as noted on the plans. Use galvanized rigid metal conduit (RMC) for exposed conduit.
- **Grounding System Devices and Equipment**:
  - Ground rods must be ¾ in. x 10 ft., copper clad steel.
- **Ground rod and cable connections underground**: Exothermic weld such as Cadweld or ThermOweld.
- **Boxes**:
  - Manufactured pull boxes must be one piece stamped galvanized steel, machine screw fasteners with ground bond screw, UL listed.
- Direct burial handholes must be constructed of reinforced fiberglass with a cover rated for “heavy duty” traffic. Size must be as specified or as required by code, whichever one is larger. Provide by Quazite, Armorcast, or approved equal.
  - Conduit fittings must match conduit type.
- Outlet, junction, and switch boxes must be cast, Type FS or FD. Cast boxes must be by Appleton, Hubbell, Killark, Thomas & Betts, or approved equal.
- Group surface mounted devices in multi-gang cast box. The size must be governed by the intended use.
  - Exterior wall surfaces or otherwise exposed to weather must be cast FD boxes with threaded hubs and UL Listed.
  - Pull boxes: construct of code gauge galvanized sheet steel with screw cover.
  - Where installed below the operating level slab, in damp or wet locations, or outdoors, boxes must be Type 316 Stainless Steel, NEMA 4X.
- Conductors
- Provide wire and cable that is UL listed, 600-V, Type XHHW with 75-degree C rating.
- Provide insulation in accordance with the latest edition of ICEA S-68-516, NEMA WC-8, UL 44, and IEEE 383.
- Supply conductors that are soft annealed copper per ANSI/ASTM B-8, Class D, stranded.
  - The minimum allowable size of wire and cable is No. 12 AWG for power and No. 14AWG for control.
  - Use heat shrink tubing with sealant to seal any splices in wet wells.
  - Wire Connectors: For connections of one or more #10 AWG or smaller, solderless twist-on connectors must be used. The connectors must have an outer insulating shell manufactured from nylon material and must be formed with “S”-shaped fins to improve twisting. The spring insert must be a helical elongated coil formed from square spring steel to cause the spring to have “live action” and reduce turning friction. The connectors must be rated flame and heat retardant for up to 105-degrees C maximum and be listed for UL 486. Conductors #8 AWG and larger must be terminated, spliced, or tapped wherever practicable with Thomas & Betts color keyed series 54000 tool applied compression connectors or approved equal.

- Terminations: Belleville type compression washers must be used when ambient temperature exceeds 30°C, T&B Series 60800, STS Industrial, or equal.
- **Compression tools**: All compression connectors must be made with manufacturers recommended tool incorporating a rachet release type mechanism to insure complete compression.
- Provide wire fastening products where wiring is required to be secured. Wire fastening products must include but not be limited to the following components: natural nylon cable ties, black (UV-resistant) cable ties, cable tie mounts, adhesive cable tie mounting pads, adhesive press clips, molded nylon clamps, molded polypropylene clamps, flat nylon clamps, and adhesive-mount adjustable clamps.
  - Use pulling lubricants on raceway wiring. Pulling lubricants must be of a greaseless compound, non-corrosive, non-conductive, non-combustible, no n-toxic, for use with PVC or steel raceways and safe for use on UL-listed wire insulation. The pulling lubricant must be Quick-Slip by Buchanan, Ideal, or approved equal.
- **Supporting Devices**:
  - Secure materials to the structure by inserts cast in concrete, expansion anchors in concrete block, machine screws or bolts on metal surfaces. Hardware must be Type 316 stainless steel. Hangars must be as follows:
    - Channel: Type 316 stainless steel by Kindorf, Unistrut, Globe Strut, or B-Line.
    - Channel Fittings: Type 316 stainless steel by Kindorf, Unistrut, or B-Line.
    - Conduit Hangars: Type 316 Stainless steel clevis type by Unistrut, Kindorf, or Grinnell.
    - Wall Anchors: Expansion bolt, toggle bolt, or other approved structural anchor. Hardware must be Type 316 stainless steel.
  - For electrical materials and components secured to joists, fasten to the top member of the joist.

4.11.2. **Execution**.

4.11.2.1. **Preparation**: Check door swings and clearances with equipment, cabinets, appliances, and coordinate with the plans before performing work.

4.11.2.2. **Installation**. Exposed wiring and conduit must be installed in a neat and workmanlike manner with runs plumb and parallel to walls. Bends and offsets must be avoided where possible, but where necessary must be made with an approved conduit bending machine. Conduit or tubing which has been crushed or deformed in any way or has begun to rust must not be installed. Use expansion bolts to secure equipment, conduit, or devices. Conduits or tubing must be supported on approved types of stainless-steel wall brackets, ceiling trapeze or pipe straps, secured by means of expansion bolts in concrete or brick. Nails must not be used as a means of fastening surface boxes or conduits. Conduit or tubing must be installed in such a manner as to insure against trouble from collection of trapped condensation and runs on conduit must be arranged as to be devoid of traps wherever possible.

Raceways must meet requirements of the National Electrical Code and local codes.

Liquid-tight flexible metal conduit must be used for connections to motors and other electrical equipment subject to movement or vibration. Maximum length must not exceed 3 ft.

Wire and cable must be continuous without splicing from load to source to supply. Splicing must only be performed after obtaining written approval.

Wire and cable, including grounds, must be run in conduit unless written permission is obtained.

Provide clamps made of stainless steel. Multiple runs of conduit must be supported on metal channel with conduit clamps. Trapezes must be metal channel with conduit clamps.

Penetrations through concrete walls, floors, and footings, both interior and exterior must be sleeved and caulked with grout or plastic compound to provide watertight seal.

Bends must be kept in conformance with minimums recommended by manufacturer. Cables must be paralleled on reels and be pulled directly into raceway from the coils or reels on which they are received. Cable must not be laid on the ground.

Use pulling lubricants on raceway wiring. Wire and cable must be installed only after raceways are free of obstruction and clean. All wire must be color coded. Wiring must be tagged with Brady "Quick" labels at terminations with each individual wire with a unique identifying number. Wiring in panelboards and terminal cabinets must be neatly trained and served.

Install empty conduits complete with a nylon pull cord.

4.12. **Service Distribution**. Install complete electrical distribution system, underground conduits and trenches, and backfill as required. Perform infrared testing of motor control center, panelboards, VFD's, and automatic transfer switch.

4.12.1. **Submittals**. Submit cut sheets on items of electrical equipment. Include panelboards, switches, wiring, receptacles, motor starters, disconnect switches, wiring devices, cover plates, nameplates, distribution equipment and overcurrent devices.

4.12.2. **Infrared Testing**. Employ an independent certified testing laboratory to inspect and test the motor control center, panelboards, and automatic transfer switches. Perform infrared tests to determine that the terminations are tightened to proper torques and that no part of the equipment is overheating beyond normal operating conditions. Perform this test twice, once at 1 week after substantial completion of the project.

4.12.3. **Products**.

4.12.3.1. **Lighting Panelboard**. Provide the lighting panel with circuit breakers that have the capacity indicated on the plans. Locate the top operating handle a maximum of 6.5ft. above the finished floor. Provide typed panel directory in panel. Incorporate panel as an integral part of the Motor Control Center.

4.12.3.2. **Circuit Breakers**. Thermal magnetic type, tripping free of handle. Handle must have three distinctive positions: 'OFF,' 'ON,' and 'TRIPPED.' Provide solid state trip units where indicated on plans.

4.12.3.3. **Thermal-Manual Motor Starters**. Unless otherwise indicated on the plans, thermal-manual motor starters must be line-voltage type with thermal over-load protection and red "run" pilot light. Thermal Manual starters must be quick make and break, toggle operated, trip free, and must be provided with lock off handle guard. Where required for automatic operation by a remote pilot device, thermal-manual motor starters must be provided with a "hand-off-automatic" selector switch, in addition to the "on-reset-off" toggle switch. Thermal-manual motor starters must be wall mounted with stainless steel plates. Thermal manual motor starters must be rated 30 amps, Square D Class 2510, Eaton, or approved equal.

4.12.3.4. **Magnetic Motor Starters**. Magnetic motor starters must be full voltage; horsepower rated, across the line starting with 120V control. Provide 120V control transformer with fused secondary. Motor starters must be NEMA rated. Provide green "run" and red "stop" pilot lights mounted in cover. Pilot lights must be provided with factory-finished legend plates indicating "stop," "run," etc. Pilot lights must be provided with interlocks controlled by the starter operating coil.

Provide solid state overload relays with the following features:

- Switch or dial selectable for motor running overload protection
- Sensors in each phase
- Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

Provide reset button, run time meter, start counter, and Hand-Off-Automatic switch for each starter. Items must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the enclosure.

For each starter, provide at least four auxiliary spare contacts (2 N.O. and 2 N.C.) for interlocking and automatic operation. Contacts must also be convertible from N.O. to N.C.

Three phase starters must have phase monitors that must automatically shut down the load during single phase conditions.

4.12.4. **Wiring Methods**. Branch circuit wiring for switches, lighting, and receptacles must be exposed on walls and ceilings. Wiring must be supported in conformance with provisions in the National Electrical Code and local code requirements and must use approved fasteners and clamps. Conduits secured to walls must be fastened to wall studs where spacing permits. In all cases, conduits and clamps must be rigidly secured and free of obstruction which may cause injuries.

All conductors must be color coded:

- 480/277V System: Brown, Orange, Yellow
- 208/120V System: Black, Red, Blue
- **Neutral**: White
- **Ground**: Green

No. 8 AWG or larger conductors must have NEC required color coding as:

- Solid color compound or solid color coating
- Colored, pressure sensitive plastic tape. Tape must be applied in half overlapping turns for at least 3 in. for terminal points, and in junction boxes, pull boxes, troughs, manholes, and handholes. Tape must be 3/4-in. wide with colors as specified above. The last two laps of tape must be applied with no tension to prevent possible unwinding.

4.12.5. **Wiring Devices**. Light Switches: Switches must be extra hard use, commercial premium specification grade and comply with Federal Specification W-S 896B and rated at 20 amps and voltage as dictated by the system. They must be approved for control motors up to 80 percent of the switch rating and must be quiet AC type. Use single pole, double pole, three-way or four-way as shown.

Receptacles: Receptacles must be extra hard use, commercial premium specification grade, two pole, three wire, and straight blade type and must comply with Federal Specification W-C 596E with a rating of 20 amp for single receptacle circuits or as indicated on the plans.

Outlets and switches must be brown in color.

Ground Fault Interrupter devices must be duplex receptacle type and must comply with UL standard 943, class A. They must be no more than 1-1/8 in. deep with standard terminal screw connections and feed-through capability rated at 20 Amps.

Receptacles must have weatherproof boxes with while-in-use covers. Switch and other device plates must be stainless steel. Depth must be suitable for sump-pump plug.

Emergency stop push buttons must be snap-type maintained contact mushroom style switches. Allen Bradley 800 series, Square D, s or approved equal.

4.12.6. **Connections to Mechanical Equipment**. Carefully make a note other equipment requiring electrical power to be furnished to fully understand wiring and motor starting requirements.

Furnish and install an enclosed disconnect switch and motor starter for each motor installed unless specifically indicated as furnished with the equipment.

Furnish and install power wiring for motors complete from Motor Control Center or panelboard, through motor starter, to motor terminations.

Provide disconnect switches where shown on the plans or as required by the NEC, fused or unfused as required, Heavy Duty and must be Square D Class 3110, Eaton, or approved equal. Any switch installed outdoors or below grade level in the pump station must be rated NEMA 4X and must be Type 316 stainless steel. Provide option to allow locking in open and closed position.

4.12.7. **Fuses**. Coordinate fuse ratings with utilization equipment limitations of maximum fuse size. Furnish and install three extra fuses of each type and rating used.

Subject to compliance with requirements, supply fuses from one of the following manufacturers:

- Cooper Bussman,
- Feral Shawmut, or
- Littlefuse.

Cartridge fuses: Provide NEMA FU1, non-renewable cartridge fuses, class and current rating indicated; voltage rating consistent with circuit rating.

Fuse Applications:

- **Motor Branch Circuits**: Class RK1, time delay
- **Other Branch Circuits**: Class RK1, time delay

Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

Install labels indicating fuse replacement information on inside door of each fused switch.

4.12.8. **Motor Starters and Controls**. Install items in conformance with manufacturer's instructions. Provide interlocks, contacts, pilot lights, and Hand-Off-Auto switches for starters. Provide starters, push buttons, etc. Mount motor starters on wall and install suitable stainless-steel enclosures and cover plates. Set overload devices to suit motors provided. Connect motors with a maximum 3 ft. length of liquid tight flexible metal conduit at motor connection.

4.12.9. **Grounding**. Provide ground bond to cold water services and to ground rods. Bond non-current carrying metallic parts of equipment, mechanical systems, and building steel. Neutral conductor at main switches must be grounded. Ground bus must not be less than size required by National Electrical Code and local codes. Grounding system must be complete and installed in conformance with local jurisdictional requirements. Ground rods must be copper clad steel, driven as indicated. Where soil conditions are poor, notify the engineer so that supplemental grounding may be considered. Ground and bond piping systems and building steel within building as required by the NEC.

Temporary Service. The Contractor must make the necessary arrangements and provide temporary electric service and lighting required during the entire construction period. The metered costs of electricity used must be borne by the Contractor upon final acceptance. The electric service must be of enough capacity and characteristics to supply the proper current for the various types of construction tools, motors, welding machines, lights, heating plant, pumps, and other work required. All necessary temporary wiring, panelboards, outlets, switches, lamps, fuses, controls, and accessories must be provided. Exact location of temporary service delivery point must be agreed upon by utility company and Department. Contractor's installation of temporary service must comply with applicable codes and regulations and must include ground fault interrupters.

Power Company Coordination. Contractor must provide site facilities as per power company's requirements. Contractor must not do any rough-in of empty conduits, transformer pads, meter sockets, etc. until the utility company has produced engineered drawings indicating exact locations and conduits required.

4.12.10. **Execution and Installation**. In general, install switches and receptacles in locations shown on the plans. Conduit and wiring for switches and receptacles must be exposed on walls. Study general building plans in relation to space surrounding each device in order that intended work may accommodate other specific work and must make minor adjustments as needed. Install boxes in a rigid and satisfactory manner. Support boxes independent of raceways. Adjacent wall mounted wiring devices, room thermostats, or other equipment must be coordinated so located either at the same elevation or in line, one above the other. Install conduit, outlets and equipment to clear beams or obstructions. Do not cut into or reduce the size of any load-carrying member without the approval of the Engineer. Obtain permission of Engineer before cutting any existing structure concrete walls or floors. Check drawings and work of others to prevent interference. Perform deviations of work to avoid obstructions as determined without additional cost.

Ground equipment in conformance with the National Electrical Code requirements and utility company requirements.

Mounting heights, unless otherwise specified:

- **Receptacles**: 48 in. above finished floor
- **Wall Switches**: 48 in. above finished floor

All wiring devices must be wired using the screw terminals. Push connections are not acceptable.

Support pull boxes and junction boxes in ceiling from structure and not from raceways or ceiling suspension system.

Use locknuts and insulating bushings at rigid conduit ends at junction boxes, pull boxes, panel, starters, disconnect switches, and other boxes.

Protect conduit openings and do not pull wire until work which would damage wire has been completed near ends of conduit. Furnish empty raceways with nylon pull strings.

Bend conduits with a conduit bender, where bends are necessary.

When cutting conduit, square ends, thread, ream, and clean.

Use gasketed covers and threaded raceway hubs for exterior raceway connections. Use vandal resistant hardware at outdoor locations.

Label safety switches, disconnect switches, motor starters, and other equipment with engraved laminated plastic tags, not smaller than 3/8 in. high, indicating function served. Letters must not be smaller than 1/4-in. high and must be black on white background. Submit proposed designations and sample for approval.

4.13. **Grounding**. Secondary service neutrals must be grounded at the supply side of the secondary disconnecting means and at the related transformers. Ground metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in proximity with electrical circuits for personnel safety and to provide a low impedance path for possible ground fault currents.

4.13.1. **Submittals**. Submit catalog cut sheets and descriptive literature for approval in accordance with Article 3, Operations and Maintenance Manuals. Include enough information clearly presented to determine compliance with plans and specifications.

- **Submittals**: Ground Rods, connectors, and exothermic welding system

- Submit and certify test reports from the NETA approved testing agency of ground resistance to the engineer. Reports must indicate date, time, temperature, and equipment used for ground resistance testing, by manufacturer and model number.
- Test grounding systems in conformance with NETA standards and summarize in the report.

4.13.2. **Products**. Ground wires must be UL and NEC approved types, copper, with green insulation, except where otherwise shown on the plans or specified.

4.13.3. **Execution**. Connect the secondary service neutral to the ground bus in the service equipment. Provide a ground loop with at least three ground rods and foundation ground connection and connect to the service equipment ground bus.

4.13.3.1. **Service Entrance Motor Control Center**. Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors. Connect the various feeder green grounding conductors to the ground bus in the enclosure with suitable crimped pressure connectors. Connect the grounding electrode conductor to the ground bus. Connect the neutral to the ground bus. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and ground wire to the ground bus.

4.13.3.2. **Conduit Systems**. Ground metallic conduit systems. Conduit systems must contain a grounding conductor. Metallic conduit provided for mechanical protection and containing only a grounding conductor must be bonded to that conductor at the entrance and exit from the conduit. Use grounding bushings for feeder conduits attached through concentric knockouts regardless of system voltage.

4.13.3.3. **Feeders and Branch Circuits**. Install green grounding conductors with feeders and branch circuits.

4.13.3.4. **Boxes, Cabinets, Enclosures, and Panelboards**. Bond the grounding wires to each pull box, junction box, outlet box, cabinets, and other enclosures through which the ground wires pass. Provide lugs in each box and enclosure for ground wire termination. Provide ground bars in panelboards, bolted to the housing, with enough lugs for terminating the ground wires.

4.13.3.5. **Motors and Starters**. Provide lugs in motor terminal box and starter housing for ground wire termination. Make ground wire connections to ground bus in motor control center.

4.13.3.6. **Receptacles**. Receptacles must have a ground wire from green ground terminal to the outlet box ground screw, regardless of type, except for isolated ground devices.

4.13.3.7. **Lighting Fixtures**. Fixtures must have a green ground wire included with the power wires.

4.13.3.8. **Electrical Appliances, Pipe, and Equipment**. Provide fixed electrical appliances and equipment with a ground lug installed for termination of the green ground conductor. Bond the water main with #6AWG conductors.

4.13.3.9. **Ground Resistance**. The grounding system must be provided and tested in the presence of Department to ensure that the ground resistance does not exceed 5 ohms. One week notice must be given before the scheduled test and the engineer must also have the option to witness the testing. Service at power company interface points must comply with the power company ground resistance requirements. Necessary modifications to the ground electrodes including driving of additional electrodes for compliance must be without additional cost.

4.13.3.10. **Ground Rod Installation**. Drive each rod vertically for not less than 10 ft. and bury at least 30 in. below finished grade. Locate the ground rods at least 10 ft. apart from each other. Submit a proposed location of the ground rods as part of the conduit layout plan for approval. Where required to obtain the specified ground resistance, install multiple rods, but in no case less than 3 rods. For ground rods, make the connections by the exothermic process to form solid metal joints.

4.14. **Low Voltage Transformers**. This Section includes dry-type transformers rated 600V and less.

4.14.1. **Submittals**. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices, features, and performance for each type and size of transformer indicated.

4.14.2. **Quality Assurance**. Testing Agency Qualifications: An independent agency, with the experience and experience and capability to conduct the testing indicated, that is a full member company of NETA and that is acceptable to authorities with jurisdiction.

Source Limitation: Obtain each transformer type through one source from a single manufacturer.

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing a testing agency acceptable to authorities with jurisdiction and marked for intended use.

Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

4.14.3. **Products**.

4.14.3.1. **Available manufacturers**. Subject to compliance with requirements, offering products that may be incorporated into the work include, but are not limited to, the following:

- Square D; Schneider Electric,
- Eaton, and
- G. E. Company

4.14.3.2. General Transformer Requirements.

- **Description**: Factory-assembled and tested, air cooled units for 60-Hz service;
- **Cores**: Grain: oriented, non-aging silicon steel;
- **Coils**: Continuous windings without splices except for taps
  - Internal Coil Connections: Brazed or Pressure type
  - Coil Material: Copper

4.14.3.3. Distribution Transformers.

- Comply with NEMA ST 20 and list and label as complying with UL 1561
- **Cores**: One leg per phase
- **Enclosure**: NEMA 250, Type 2 unless noted otherwise
- Core and coil must be encapsulated within resin compound, sealing out moisture and air
- Tap for transformers 7.5kVA to 24 kVA: one 5% tap above and one 5% tap below normal full capacity.
- Taps for transformers 25kVA and larger: Two 2.5% taps above and two 2.5% taps below normal full load capacity.
- Insulation class: 220 degree C, UL component recognized insulation system with a maximum of 115 degree C rise above 40 degree C ambient temperature. The 115 degree C rise transformers must be capable of carrying a 15% continuous overload without exceeding a 150 degree C temperature rise.
- Transformers 15 kVA and larger: comply with NEMA TP 1, Class 1 efficiency levels and tested according to NEMA TP 2.
- Electrostatic shielding: Each winding must have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

4.14.4. **Execution**.

4.14.4.1. **Examination**. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer. Verify that field measurements are as needed to maintain working clearances required by

NFPA 70 and manufacturer's written instructions. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers are installed. Verify that ground connections are in place and requirements of Division 16 Section "Grounding" have been met. Maximum ground resistance must be 5 ohms at location of transformer. Proceed with installation only after unsatisfactory conditions have been corrected.

4.14.4.2. **Connections**. Ground equipment according to "Grounding" Section.

4.14.4.3. **Field Quality Control**. Engage a qualified testing agency to perform tests and inspections and prepare test reports. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters. Remove and replace units that do not pass tests or inspections and retest as specified above.

Infrared Scanning. Two months after substantial completion, perform infrared scan of transformer connections. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

4.14.4.4. **Adjusting**. Record transformer secondary voltage at each unit for at least 48 hr. of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3% at maximum load conditions. Submit recording and tap settings as test results.

Output Settings Report: Prepare a written report recording output voltages and tap settings.

4.14.4.5. **Cleaning**. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

4.15. **Lighting**. Provide lighting including furnishing, storing, installing, and connecting fixtures, complete for continuous satisfactory operation. Included is furnishing lamps, mounting brackets, stems, escutcheons, frames, and trim required to match surrounding surface.

4.15.1. **Submittals**. Contractor must verify ceiling types and coordinate trip and mounting hardware before submission of fixtures and must have final responsibility to insure proper compatibility of fixture type with ceiling system.

Manufacturer's model and catalog numbers change frequently and may not necessarily include features or options as specified herein or required for complete installation. In particular, catalog number may only indicate type and series of required fixture. When specified types, finishes, features, options, and accessories conflict with a given model number, former must govern.

Submit cut sheets for fixtures furnished. Submittals will not be checked for proper or complete catalog numbers.

Under base bid, furnish fixtures and equipment specified or named equals. Where no named equal is given and only "Or approved equal" is noted, Contractor may at his option use alternates of his selection. However, such alternate must conform to the specified fixture's construction, performance, and catalog features and must have a similar aesthetic appearance. Failure to conform will result in rejection of item.

4.15.2. **Products**. Provide products meeting the following requirements.

- **Color temperature**: 4000K
- **Rated Lamp Life**: 50,000 hours
- Light fixtures must bear label of Underwriters' Laboratories, Inc. and must be suitable for intended location. Fixtures must be labeled indicating suitability for damp or wet locations where required.

- Each fixture must be supplied with necessary straps, supports, or hangers, or other miscellaneous materials and devices to install them in a satisfactory manner to conform to architectural treatment and finishes in area in which they are installed.

Fixtures furnished must be standard manufacturer's cataloged and stocked fixtures. Specially fabricated fixtures, unless so specified, will not be accepted. Replacement parts and lenses must be readily available from manufacturer. Fixture voltages must be as shown to be connected on the plans. Lighting fixture schedule: (Refer to plans).

4.15.3. **Execution**.

4.15.3.1. **Installation**. Support fixtures from structure above, provide rigid hangers or framing to support units.

Coordinate fixture locations with ceiling framing and equipment locations. Align continuous row fixtures in uniform rows. Furnish metal channels to achieve alignment, if required. Securely support fixtures with approved hangers. Such hangers must be set in perfect alignment and elevation.

Outlet mounted fixtures must be mounted directly to mounting ears of outlet box or to fixture studs as required by selected fixtures. Furnish structural supports for heavy fixtures.

Carefully place splices in outlet boxes or wiring gutters with no crowding in a neat and orderly manner.

4.15.3.2. **Guarantee**. Unless otherwise specified, unconditionally guarantee for period as set forth in General Conditions, material, equipment, workmanship, and installation. During this period, adjust, repair, or replace at no cost to the Department, any item or equipment or workmanship found to be defective.

LED fixtures must be guaranteed for at least 5 yr. after substantial completion.

4.16. **Automatic Transfer Switch**. Provide solid state logic automatic transfer switch by Schneider Electric, Eaton, or Russel Electric. Mount the switch as part of the MCC as shown on the plans and must be delayed transition type with center-off position between the two available sources.

4.16.1. **Submittals**. Submittal must include specification sheets showing standard and optional accessories to be supplied; schematic wiring diagrams; dimension drawings; and interconnection diagrams identifying by terminal number each required interconnection between the generator set, pump control panel, and transfer switch.

4.16.2. **Switch Operation**: Provide a four-pole switch with switched neutral.

Provide an automatic transfer switch three-phase control panel that uses solid-state sensing for automatic, positive operation. Provide the following:

- The normal or preferred source voltage across live lines must be monitored line-to-line. Close differential voltage sensing must be provided. The pickup voltage must be adjustable from 75% to 100% of nominal. The dropout voltage must be adjustable from 70% to 98% of the pickup value. The transfer to emergency/secondary will be initiated upon reduction of normal/preferred source to 85% of nominal voltage and retransfer to normal/preferred must occur when source restores to 95% of nominal.
- A test switch to momentarily simulate normal/preferred source failure.
- Harnessing between transfer switch and control panel must have built-in disconnect for routine maintenance.

The moveable parts of the operating mechanism must remain in positive mechanical contact with the main contacts during the transfer operation without the use of separate mechanical interlocks. Automatic operation

of the switch must not require power from any source other than the line-to-line voltage of the source to which the switch is transferring.

4.16.3. **Products**.

4.16.3.1. **Equipment**. The automatic transfer switch must consist of a power transfer module and a control module, interconnected to provide complete automatic operation. The automatic transfer switch must be mechanically held and electrically operated by a single solenoid mechanism energized from the source to which the lead is to be transferred. The switch must be rated for continuous duty and be inherently double throw. The automatic transfer switch must be suitable for use with emergency sources, such as engine or turbine generator source, or with another utility source.

Main contacts must be of silver composition. The operating transfer time in either direction must not exceed 1/6th of a second.

Contacts, coils, springs, and control elements must be conveniently removable from the front of the transfer switch without major disassembly or disconnection of power conductors.

Supply a control module with a protective cover and mount separately from the transfer switch for ease of maintenance. Sensing and control logic must be solid state and mounted on plug-in printed circuit boards. Printed circuit boards must be keyed to prevent incorrect installation. Interfacing relays must be industrial control grade, plug in type with dust covers and locking clips.

Automatic transfer switches utilizing components of molded case circuit breakers, contactors, or parts thereof which have not been intended for continuous duty or repetitive load transfer switching are not acceptable.

The automatic transfer switch must conform to the requirements of NEMA standard ICS 2-447 and UL-1008. Automatic transfer switch must be UL listed for use in emergency systems in accordance with Articles 517 and 700 of the National Electrical Code and rated in Amperes for total system transfer including control of motors, electric heating, and LED fixtures.

The automatic transfer switch must be rated to withstand the manufacturer's standard rating for symmetrical amperes short circuit current based on the coordinated circuit breaker.

The automatic transfer switch must be mounted as part of the motor control center as indicated on the plans.

The automatic transfer switch must be delayed transition.

4.16.3.2. Accessories.

- Switches must include a time delay on transfer from normal/preferred to emergency/secondary, field adjustable from 6–60 sec.
- Switches must be a time delayed transition type with a center position available between the two available source positions.
- Switches must include a time delay on retransfer from emergency/secondary to normal/preferred, field adjustable from 1 to 30 min. The time delay must be automatically bypassed if the emergency/secondary source fails and the normal/preferred source is available.
- The switches must include voltage and frequency sensing of the emergency/secondary source and must be factory set to allow transfer to emergency/secondary when that source is at approximate rated voltage and frequency.
- Contacts rated 10 Amps, 32 Volts DC which close when the normal source fails must be provided to initiate engine starting, where applicable. Provide signals between automatic transfer switch, generator, and pump control panel as shown on the plans.

- Switches must include a time delay to ignore momentary outages. It must delay closing of the engine start contacts for an adjustable time from 0.5 to 6 seconds.
- Switches must include a time delay for engine cool down, adjustable from 0 to 15 minutes.
- One auxiliary contact closed when the switch is in the normal/preferred position and one closed when the switch is in the emergency/secondary position must be provided. Contacts must be rated 10 amps, 480 volts AC. Provide signals to the pump control panel as shown on the plans.
- Two pilot lights to indicate switch in normal/preferred or emergency/secondary position must be installed in the door of the enclosure.
- Two contacts must be provided which close when the generator runs and opens when the generator stops. They must be rated 10 amps, 120 volts. Provide signals to the pump control panel as shown on the plans.
- A plant exerciser that is (7-day, time adjustable more than 30 min.) field adjustable for exercising the generator on 30-min. increments must be provided. Provide a selector switch for load/low load operation.
- Outputs must be provided to the generator for control and to the pump control panel form monitoring and alarm as indicated on the plans.
- Switches must be provided with auxiliary contacts to indicate normal utility power failure.

4.16.4. **Execution**.

4.16.4.1. **Testing**. Perform the following tests.

- Certified laboratory test data on a switch of the same design and rating must be provided to confirm the following switch abilities:
- Overload and endurance per Tables 21.2 and 23.2 of UL-1008 when enclosed according to Paragraph 1.6
- Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits of the insulation in contact with current carrying parts.
- Withstand current tests per Paragraph 25 of UL-1008 for 5000A rms symmetrical, at 480V and X/R ratio of 6.6.
- No welding of contacts. Transfer switch must be operable to alternate source after they withstand current tests.
- Test remote monitoring and alarm signals to and from all sources and the pump control panel.

Production units should be subjected to the following factory tests:

The complete automatic transfer switch must be tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency, and time delay settings are in compliance with the specification requirements.

The complete automatic transfer switch must be subjected to a dielectric strength test per NEMA Standard ICS 1-109.05.

The control panel must meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 and the impulse withstand voltage test in accordance with the proposed NEMA Standard ICS 1-109.

An authorized representative of the switch manufacturer and Engineer must attend start-up activities to assist the Contractor with installation, testing, and certifying the system.

4.16.4.2. **Certification**. The manufacturer must provide a letter certifying compliance with requirements of the transfer

switch specifications. The certification must identify equipment by serial number and must include no exceptions to the specifications, except those stipulated with the submittal.

4.16.4.3. **Guarantee**. Each transfer switch must be provided with an operator's manual providing installation and operating instructions.

4.17. **Standby Generator**. Provide a standby power generator system in conformance with the plans and specifications. Perform work in conformance with NFPA, NEMA, and IEEE standards.

4.17.1. **Quality Assurance**. The standby generator system, including engineer-generator set, generator, and generator controls, must be furnished by a single manufacturer who has been regularly engaged in the production of engine generator sets, generators, engine auxiliaries, and controls for at least 10 yr. The manufacturer must have a local representative who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.

The generator set and controls must provide a completely automatic unattended operation for the duration of a loss of normal utility power. All controls must be the standard of the manufacturer.

The generator set manufacturer must assume full responsibility for correct operation of the entire standby power generator system, including the fuel distribution system.

Final Production Tests:

- Each generator set must be tested under varying loads with guards and exhaust system in place before shipment of the standby power generator system.
- Final production tests must include Single-step load pickup, transient and steady state governing, safety shutdown device testing, voltage regulation, rated power, maximum power.
- The specified generators are to be used to start and run large motors.

The standby power generator system must be guaranteed in writing for defects in materials and workmanship for a period of 5 yr. from the date of substantial completion. Multiple warranties for individual components such as engine, alternator, and controls, will not be acceptable. The warranty must be comprehensive, and must include parts, labor, travel, and other miscellaneous expenses.

In addition to the stipulated guarantee, the generator manufacturer or his approved agent, must provide a comprehensive service contract for a period of 5 yr. from the date of substantial completion. The service contract must cover necessary parts, labor, travel, and other services required to keep the generator in complete working order at all times. The only items excluded from the service contract must be fuel and regular oil changes and lubrication.

4.17.2. **Submittals**. Provide the following submittals:

- Shop drawings showing fabrication, assembly, foundation, and installation.
- Catalog data and detailed specification sheets for standard and optional accessories to be supplied.
- Wiring diagrams and electrical schematics indicating operation, controls, and power supply.
- Operation and maintenance manual for standby power generator system.
- Certified copies of manufacturer's final production test results.

4.17.3. **Materials**. Equipment specified for the standby power generator system must be manufactured by Caterpillar, Cummins, or approved equal. Generator must have a rating as indicated herein or on the plans. Basis of design for generator is Caterpillar. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the Contractor with no extra cost to the Department.

4.17.3.1. **Engine-Generator Set**. Mount the engine-generator set on a structural steel base to maintain proper alignment between components. The structural steel base must incorporate vibration isolators of the type

and quantity recommended by the manufacturer to obtain at least 95% vibration attenuation.

Engine must be liquid cooled for use with natural gas.

The engine must be furnished with the following accessories:

- Replaceable full-flow oil filters and oil drain valve with hose extension. Provide two spare of each filter.
- Replaceable dry element air cleaner. Provide two spare of each filter.
- Replaceable fuel filters. Provide two spare of each filter.
- Provide two spare of each type of belt.
- Electric starting systems, including starting motor, batteries, battery charger, cables, and battery rack. Provide float/equalize battery charger. Batteries must be provided with cold cranking amp capacity 25% higher than the manufacturer's standard for the unit provided.
- Batteries must be lead-acid or nickel cadmium type and battery charger must include temperature compensation feature with voltmeter and ammeter to indicate battery charging voltage and current.
- Safety devices to protect the engine against high and low coolant temperature, low lubricating oil pressure, overspeeding, and overcranking.
- Engine-mounted, thermostatically controlled jacket water heater rated as required. The heater must be disconnected by an oil pressure switch mounted on the engine when the engine starts.
- Unit mounted radiator with engine driven fan.
- Instrument panel with lubricating oil pressure gauge, water temperature gauge, and battery charging ammeter.
- Hospital type (critical) exhaust silencer sized as directed by the generator set manufacturer. Provide thermal insulation jacket. All silencers and the straight pipe section from the silencer to the wall thimble must be wrapped with high temperature-flexible insulation which conforms to Military Specification MIL-I-16411-E, Type II. Insulation must be Type E Fiberglass Insulation designed for use in insulating high temperature equipment as manufactured by Advanced Thermal Products, Inc. or equal. Insulation must be flexible, lightweight and must not compact under vibration. Insulation must be manufactured from chopped glass fibers and must be free from resinous binders. Insulation must be installed in conformance with the manufacturer's recommendations.
- All necessary piping, stainless steel flexible exhaust tubing, fittings, mounting hardware, flapper type exhaust cap, and other equipment necessary to complete the exhaust system must be provided. Exhaust pipe opening through generator enclosure or building must be made weatherproof, and vermin-proof. Provide manufacturer approved wall thimble.
- The generator set supplier must furnish lubricating oil to fill the crankcase and 50 percent ethylene glycol antifreeze solution to fill the engine cooling system.
- Unit mounted main circuit breaker.

4.17.3.2. **Generator**. Provide an alternator that is salient-pole, brushless, 12-lead reconnectable, of 2/3 pitch to eliminate the third harmonic, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed for smooth voltage waveform. The insulation must meet the NEMA standard (MGI-22.40 and 16.40) for Class H and be vacuum, impregnated with epoxy varnish to be fungus resistant per MIL 1-24092. Temperature rise of rotor and stator must be limited to NEMA Class F. The excitation system must be brushless construction controlled by a solid-state voltage regulator located in the switchgear.

Frequency regulation must be isochronous from no load to rated load. The voltage regulator must be solid-state design and must provide no load to full load regulation within ±1% of rated voltage during steady-state conditions.

Performance criteria must be equal to the specified equipment. A rheostat must provide at least a range of ±10 percent voltage adjustment from rated value.

The alternator, exciter, and voltage regulator must be designed and manufactured by the generator set manufacturer so that the characteristics are matched to the torque curve of the prime mover. The system must provide automatic voltage reduction if the load demand exceeds the engine capacity to prevent engine stalling and saturation of magnetic components. Systems that routinely select a linear-type (straight line) constant volts per hertz characteristic without regard for the engine power and torque characteristics are unacceptable.

Upon one-step application of any load up to 100% of the rated load at 0.8 power factor, the voltage dip must not exceed 20 percent and must recover to ±2% of rated voltage within 1 sec.

A resettable line current sensing circuit breaker with inverse time versus current response must be furnished. This breaker must not trip within the 10 sec. specified above to allow selective tripping of downstream fuses or circuit breakers under a fault condition. This breaker must not automatically reset preventing restoration of voltage if maintenance is being performed. Generator breaker must selectively coordinate with downstream overcurrent protection devices. Breaker must be provided with adjustable long time, short time, and instantaneous settings as required to achieve coordination.

The generator, with a single maintenance-free bearing, must be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

4.17.3.3. **Control System**. The standby power generator system must be provided with a generator-mounted solid-state microprocessor control and starting panel, incorporating complete controls for functions of the generator set and associated mechanisms. The panel must be of the dead front type, NEMA 1 construction and must be mounted and wired to the generator set by the engine generator set manufacturer. Control wiring must have termination identification on each wire.

Engine-generator controls must include the following:

- Two-wire, 24-V DC engine controls including oil pressure gauge, coolant temperature gauge, and charge rate ammeter.
- A manual selector switch providing three control positions, RUN-STOP-REMOTE, must be included on the console. The RUN position must permit the engine to be started locally at the sot and run unloaded; the STOP position must serve as the RESET for alarm shutdown conditions; and the REMOTE position must allow automatic starting on a signal from the pump control panel.
- Control console containing complete controls, which start the engine on closing contact, and stop the engine on opening contact. The starting controls must be operated either manually or from a contact provided on the automatic transfer switch. When the engine fires, the starting controls must be disconnected automatically. If the engine fails to fire or any safety device should operate while the engine is running, the engine must stop immediately, and the starting controls locked out until manually reset.
- Generator controller must provide overload and short circuit protection required for the generator.
- Solid-state voltage regulator.
- Manual reset field circuit breaker.
- **Control Panel mounted Emergency E-Stop**: Flush; wall mounted, unless otherwise indicated; and labeled. Push button must be protected from accidental operation.
- AC output controls including voltmeter, ammeter, frequency meter, running time meter, voltage adjusting rheostat, and speed potentiometer.

The required inputs and outputs to and from the generator, automatic transfer switch and pump control panel for control, monitoring and alarm as shown on the plans. These must include, at least:

- Utility service failure alarm,
- Generator start control,
- Generator running status,

- Generator failure alarm,
- Station on generator power status,
- Generator not in auto status,
- Low oil alarm,
- High temperature alarm, and
- Low gas pressure alarm

All alarm signals to the Pump Control Panel must be wired to terminal blocks inside the generator enclosure for customer connection.

4.17.3.4. **Outdoor Weather-Protective Sound Attenuating Enclosure**. The generator must be provided with a sound-attenuating enclosure which must allow the generator set to operate at full rated load in the ambient conditions. The enclosure must reduce the sound level of the generator set while operating at full rated load to a maximum of 75dBA at any location 23 ft. from the generator set in a free field environment. Housing configuration and materials used may be of any suitable design which meets application needs, except that acoustical materials used must be oil and water resistant. No foam materials must be used unless they can be demonstrated to have the same durability and life as fiberglass.

The enclosure must include hinged doors for access to both sides of the engine and alternator, and the control equipment. Key-locking and pad-lockable door and latches must be provided for the doors. Door hinges must be stainless steel.

Provide the enclosure with an exhaust silencer, mounted inside of the enclosure, and allows the generator set package to meet specified sound level requirements. Silencer and exhaust must include a rain cap and rain shield.

Sheet metal must be primed for corrosion protection and finish painted with the manufacturer's standard color. All surfaces of metal parts must be primed and painted.

Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts must not be acceptable. Fasteners used must be corrosion resistant and designed to minimize marring of the painted surface when removed for normal installation or service work.

Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110% of rated load for 2 hr. with ambient temperature at top of range specified in system service conditions.

Louvers: Fixed-engine, cooling-air inlet, and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

Automatic Dampers: At engine cooling-air inlet and discharge. Dampers must be closed to reduce enclosure heat loss in cold weather when unit is not operating.

Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

4.17.4. **Execution**.

4.17.4.1. **Installation**. Mount the generator and securely anchor to the concrete pad. Install the standby power generator system as indicated on the plans and in conformance with the manufacturer's recommendations.

The generator concrete pad must be as shown on the plans with at least 6-in. clearance around. Where access platforms and stairs are necessary, the Contractor must provide properly sized concrete pad as well as turn downs for the platforms and stairs.

4.17.4.2. **Field Quality Control**. Verify that fuel piping, electrical connection, and exhaust piping work is complete. Demonstrate operation with selector switch in hand-off-automatic positions. Demonstrate performance of engine water jacket heater by filling the engine cooling system with coolant at room temperature. Energize the water jacket heater, determine the load current to the heaters and verify that water is rising in temperature using hand sensation as a detector.

Automatic Transfer Switch. Verify that the transfer switch transfers to engine-generator source when normal supply voltage is less than 90% of rated voltage and retransfers when normal supply is 100% of rated voltage. Use suitable test instruments to verify voltages. Verify that failure of engine generator power source causes transfer to normal power supply by operating generator load circuit breaker. Check sensor operation to prevent transfer to emergency power until the generator output reaches 100% of voltage and frequency. Use suitable test instruments to verify voltages.

Control Panel: Electrically check automatic engine shutdown controls as the engine proceeds through its start-up sequence as follows:

- **Engine Overcrank**: Disconnect one wire from the fuel supply solenoid valve and turn the manual selector switch to the run position causing the engine to attempt to start for the period and number of cycles defined for overcrank alarm contacts to close. Verify overcrank alarm actuation and lockout. Reconnect the wire to the fuel supply solenoid valve and start the engine by turning the manual selector switch to the run position.
- **Low Oil Pressure**: Electrically short out the low oil pressure switch contacts to verify engine shutdown.
- **High Coolant Water Temperature**: Electrically short out the high coolant water temperature thermostat contacts to verify engine shutdown.
- **High Lubrication Oil Temperature**: Electrically short out the high coolant water temperature thermostat contacts to verify engine shutdown.
- **Engine Overspeed**: Manually adjust speed into overspeed range to verify engine shutdown.

Generator Remote Alarms: Provide the following alarm signals to the Pump Control Panel:

- Generator Overcrank,
- Generator Running,
- Generator Fail,
- Generator Not In Auto,
- Loss of Gas Pressure,
- Low Oil, and
- High Oil Temperature.

Engine Generator Operation

- With normal electrical power supply to transfer switch, open main circuit breaker to verify that initiating Contractor closes to start automatic sequence. Engine should start and control panel instruments should show voltage and frequency reach approximately rated value.
- Close normal power main circuit breaker. Verify that the automatic transfer switch transfers load back to normal power, initiating contactor opens, beginning the automatic stop sequence. Verify that the generator set stops automatically if the engine has a failure.
- Start and stop engine generator at least six times within a two-hour period to verify operation.
- Demonstrate that safety devices furnished for automatic engine shutdown will cause engine shutdown when actuated.

Conduct a 4-hr. load bank test on the generator and submit a field report indicating the test results.

Coordinate, connect, and test require inputs and outputs between the generator system, automatic transfer switch and pump control system.

An authorized representative of the manufacturer must attend start-up activities to assist the Contractor with installation, testing and certifying the system.

4.18. **Motor Control Center**. Furnish and install a complete motor control center including required number of vertical sections, main breaker, digital meter, surge protective device, combination type motor starters, circuit breakers, magnetic relays, selector switches, push buttons, pilot lights, control transformers and special controls as shown on the plans and specified herein. An automatic transfer switch, panelboard, and transformer must also be included in the MCC.

The motor control center must be new and limited to products regularly produced and recommended for service ratings in conformance with engineering data or other comprehensive literature. In cases where device, or devices, or part of equipment is herein referred to in singular, reference must apply to as many items as required to complete installation.

4.18.1. **Special Requirements**. The Motor Control Center must be furnished, programmed, commissioned, and tested by the Pump Control System Supplier. The electrical Contractor must install the Motor Control Center and provide conduit and wiring.

The Plans indicate certain motor starters to be energized by a programmable controller output. If the current rating of the output is not enough to energize the starter directly, provide an interposing relay in the motor starter compartment and wire the relay as required to energize the starter.

Install Motor Control Center on concrete base. Coordinate size and location of concrete base.

The dimensions on the plans for the Motor Control Center are the maximum allowable dimensions for the Motor Control Center. Provided dimensions allow for installation of the basis of design electrical components as detailed below and elsewhere on the plans and specifications. The Contractor must be responsible for any and changes in the work made necessary from the installation of equipment other than the basis of design. All changes must be done without any additional cost to the Department or delay to project completion.

4.18.2. **Regulations**. Comply with the Regulations, Standards, and Publications below.

- UL Underwriters' Laboratories, Inc.,
- NEC,
- NEMA, and
- ANSI.

4.18.3. **Submittals**. Shop drawings must be complete in respects and must indicate dimensions, installation methods, size, weight, capacity, ratings, integral controls and types of materials, elevations, and sections. Shop drawings must include manufacturer's literature and complete information on the following:

- Freestanding Vertical Sections
- Main Circuit Breakers
- Digital Meters
- Surge Protective Devices
- Automatic Transfer Switch
- Thermal magnetic Type Circuit Breakers
- Magnetic Across-the-Line Motor Starters
- Control Transformers
- Relays
- Selector Switches
- Push Buttons
- Pilot Lights
- Elapsed Time Meters
- Special Controls

- Engineered Control Diagrams and Connection Diagrams
- Nameplate Schedule
- Variable Frequency Drives and Solid-State Starters

Manufacturer. The Motor Control Center basis of design is Square D Model 6. Equivalent equipment as manufactured by Eaton Corporation is acceptable subject to approval and compliance with specific requirements listed herein. Contractor is responsible for any additional work required due to the selection of equipment other than the basis of design at no extra cost to the Department.

4.18.4. **Products**.

4.18.4.1. **Motor Control Center Structure and Configuration**. Provide a NEMA Type I gasketed MCC. Wiring must be NEMA Class II, Type C. The motor control center must have a main breaker as indicated on the plans to feed the horizontal bus. Provide lugs of adequate size to terminate incoming cables. The motor control center must be furnished with a ground bus.

Motor starter units must be combination type with a molded case circuit breaker. Control voltage for units must be 120 volts. The Motor Control Center must be rated 480V, 3 phase, 3 wire, 60Hz and must be braced to withstand a short circuit current of 65,000 rms symmetrical amps. The motor control center must consist of vertical sections bolted together to form a rigid, freestanding assembly.

Vertical sections must be formed of 13-gauge hot rolled steel with uniform blemish-free surfaces. Top and bottom structural parts must be 10-gauge. End closing plates must be 12-gauge, and unit parts and doors must be 14-gauge. Base channels must be provided constructed of rugged steel to easily withstand the stress of transit and moving the control center into position. Bolt holes in the base channels must be provided in sections for the purpose of bolting the control center to the floor. Steel removable lifting angles must be provided on the top of the sections for convenience in handling the control center.

Each section, to comply with standards of NEMA, must be approximately 90 in. high excluding lifting angles and base channels. It must be approximately 20 in. deep and width must be as required for the application or as indicated on the plans.

End sections must have end-closing plates, which can be removed for the addition of future sections. The top plate must be of a removable one-piece construction for added convenience in cutting conduit holes. Removable blank plates flanged on all four sides and with captive screws must cover unused unit spaces.

4.18.4.2. **Main Circuit Breaker**. Where shown, main circuit breakers must be provided, individually mounted, and identified. The main breakers must have enough interrupting capacity to properly close against and interrupt instantaneously, without damage, the maximum short circuit current available to the breaker. Interrupting capacity must be 65,000 amp symmetrical at 480V. The main breaker must be 100% rated. The main circuit breakers must be furnished with GFI protection. Auxiliary contacts must be provided for the main circuit breakers and the automatic transfer switch to remotely signal breaker position and switch status to the pump control system PLC.

4.18.4.3. **Digital Meter**. Provide a digital meter in the Motor Control Center to provide complete electrical metering for the active service. The digital meter must be microprocessor based and must be furnished complete with current transformers. The digital meter must be Square D PM5000, Eaton, or approved equal. Furnish a digital meter with an alarm contact for remote indication of a power failure on any individual or all three phases. Provide optional communication interface and power management software and connect via network communications to Pump Control System.

In addition to the digital meter, install a three-phase monitor to sense the presence of utility power on the line side of the utility main circuit breaker. The monitor must output a discrete signal which must be hardwired to the PLCs in the Pump Control Panel for monitoring. The three-phase monitor must be ATC Diversified Electronics SLA (230/440) ALE, Eaton, or approved equal, with voltage rating as required.

4.18.4.4. **Internal Surge Protection**. Where shown as internally mounted, furnish a surge suppressor in the Motor Control Center for each normal and emergency service feeder. The surge suppressor must be UL 1449 Second Edition Listed (1998). Unit must protect all modes (L-L, L-N, L-G, N-G) applicable. Unit must have 240kA of surge capacity per phase with a let-thru voltage of less than 1500V L-L and 700V L-G. A disconnecting means must be provided ahead of the surge suppressor so the unit can be serviced without de-energizing the service.

Unit must be furnished with dry contact alarm outputs to indicate any module failure. Surge suppressor must have AC tracking filter with EMI/RFI filtering. Each module must be fused individually, thermally protected, and have LED indication.

Unit must be provided and installed by MCC manufacturer.

4.18.4.5. **Horizontal Wireways**. Adequate conduit entrance space and wire entry room must be provided at both the top and bottom of each section. The bottom horizontal wireway must be 12 in. and the top horizontal wireway must be 6 in. and both must extend through the length and depth of the control center section with openings between sections. Covers over these wireways must be equipped with captive type screws to prevent loss of hardware during installation. These wireways must be isolated from the bus bars.

4.18.4.6. **Vertical Wireways**. Install a vertical wire trough located on the right-hand side of each standard section and with a cross-sectional area of not less than 28 sq.in. It must extend from the top horizontal wire trough to the bottom horizontal wire trough for the purpose of routing user's motor and control wires to the control units. The wire trough must be isolated from the bus bars to guard against accidental contact. A separately hinged door with captive type screws must cover the vertical wire trough for safe and easy access to wiring without disturbing control units. Wire ties must be furnished in the vertical wire trough to group and securely hold wires in place for a neat, orderly installation.

Where wire access ports between unit spaces and vertical wire trough are open, shutters must be provided to prevent items, such as a fish tape, from accidentally entering the unit space. Snap-in wire grommets must be provided in wire access ports for size 2 units and smaller for isolation and added protection of small wires. For larger units) snap-in wire guards must be provided for added protection of larger wires.

4.18.4.7. **Vertical Sections**: Divide each vertical section into compartments, each containing a combination starter, circuit breaker, or other control assembly as indicated on the plans. Provide power to these compartments from the main bus by bus bars extending the full height of the unit. Sections must also be provided with horizontal spaces at the top and at the bottom, which must line up with adjacent section to form horizontal wiring raceways along the entire length of the control center.

4.18.4.8. **Compartments**. Compartments must be built in interchangeable combinations of modular heights. A full vertical section must contain six equal NEMA size I modular compartments exclusive of top and bottom wiring spaces. Starter compartments must not be less than 12 in. high. Only 1/2 and integral multiples of the basic module will be allowed. Compartments for NEMA size 4 and smaller starters must be draw-out type.

Guide rails must be provided in the structure for supporting and aligning a unit during its removal or replacement. Draw out units must have pressure type, line disconnecting stabs of high strength alloy and must be held in place by means of quick acting, captive machine screw fasteners arranged so the units can be removed or remounted readily without access to the rear of the structure. Each compartment whether draw out or stationary, must be enclosed and effectively baffled to isolate any fault which may occur and must be covered by an individual door fixed to the structure with a continuous full length piano hinge or two (three for doors over 36 in. high) semi-concealed, heavy-duty, pin type hinges. Doors must be secured with captive, quick acting machine screw fasteners and must be arranged to completely cover live parts whether the draw out unit is present or not.

Provide doors two space factors (24 in. high) and larger with stainless-steel handles and stainless-steel hardware, for ease of opening.

4.18.4.9. **Bus Bars**. Main horizontal bus bars rated as indicated on Plans but not less than 1000 amp must be provided at the top or center of the control center and extend its entire length, except when cut and supplied with splice bars to divide the control center for ease in handling or when section is indicated on Plans to be furnished without bus.

Horizontal bus bars of copper must be mounted edge-to-edge to provide greater mechanical strength. Vertical copper bus bars must be rated at least 600 amp for adequate current carrying capacity in a variety of plug-in applications. Horizontal and vertical bus bars must be electrolytically tin-plated copper. Connections between horizontal and vertical busses must be joined by bolts, conical spring washers for constant pressure joints and self-clinching nuts to allow joint maintenance from the front.

High strength glass reinforced alkyd insulators must be used as bus supports and as unit plug-in insulators. Bus and plug-in insulators must be red to indicate the proximity of energized bus parts.

The temperature rise, above ambient temperature outside the enclosure, of bus bars and connections must not exceed 50°C and that of connections to insulated cable must not exceed 45°C when operated continuously at rated current. Buswork, wiring, and equipment must be rated to withstand short circuits of 65000 rms symmetrical amp at 480 volts or as noted on the plans.

Provide a copper ground lug in each incoming line vertical section capable of accepting a #8 to 250 MCM cable, A horizontal and vertical copper ground bus must be provided in each section of the motor control center. Horizontal ground bus must run continuously throughout the control center except where splits are necessary for ease of shipment and handling; in which case, splice bars must be provided. Ground bus must be tin plated copper and have a cross-sectional area of equal to 28% of the main horizontal bus cross-sectional area. Horizontal ground bus must be located at the bottom of the motor control center.

Where required, a full rated tin-plated copper neutral bus must be provided.

4.18.4.10. **Bus Barrier**. Insulated horizontal and vertical bus barriers must be furnished to reduce the hazard of accidental contact, these barriers must have a red color to indicate proximity to energized busses. Vertical bus barriers must have interlocking front and back pieces to give added protection on all sides and must segregate the phases from each other. Small, separate openings in the vertical bus barriers must permit unit plug-in contacts to pass through and engage the vertical bus bars.

Bottom bus covers must be provided below the vertical bus to protect the ends of this bus from contact with fish tapes or other items entering the bottom of the enclosure. Unused plug-in openings must have plastic snap-in closing plates.

4.18.4.11. **Unit Plug-in**. Unit plug-in contacts must be provided for Size 1 through Size 5 motor starters and for branch circuit breakers.

The plug-in connection must be 2-point connection for each phase designed to tighten during heavy current surge. The plug-in fingers must be tin plated to yield a low resistance connection and must be backed by spring steel clips to provide high-pressure connection points. Contact fingers must be mounted in their support so these fingers become floating and self-aligning to allow solid seating onto the vertical bus bars.

4.18.4.12. **Unit Doors**. Each unit must have a door securely mounted with hinges, which allow the door to swing open at least 112°. Unit doors must be fastened to the stationary structure, so they can be closed to cover the unit space when the units have been temporarily removed, Unit doors must be held closed with captive type screws, which engage self-aligning cage nuts. These screws must provide at least two threads of engagement to help hold unit doors closed under fault conditions, Removable door panels held captive type screws must be provided on starter unit doors for mounting push buttons, selector switches or pilot lights. Blank door panels capable of accepting future push button devices must be furnished when push button devices are not originally specified for starter units. Starter units must have an external low-profile overload reset button.

Pilot devices and instruments, including push buttons, reset buttons, and indicating lights, must be flush mounted in the compartment doors. Equipment must not be mounted on the rear of draw out units. All equipment within the unit must be arranged to provide ample electrical clearances and easy access for maintenance. Draw out combination starter unit of a given type and size must be made interchangeable. Only those items, which are common to starters, must be mounted in the unit.

4.18.4.13. **Unit Support Pan**. Each plug-in unit must be supported and guided by a tilt and lift-out removable pan, so unit rearrangement is easily accomplished. For easy unit installation and rearrangement, transfer of this unit support pan from one location to another must be accomplished without the use of tools after the unit and door have been removed.

4.18.4.14. **Unit Saddles**. Each plug-in unit must have a sheet steel saddle designed to physically isolate the unit from the bus compartment and adjacent units. Saddles must be equipped with captive, self-aligning mounting screws, which hold the unit securely in place during shipment and maintain the unit and structure at the same potential. Handholds must be provided on each plug-in unit to facilitate unit removal.

4.18.4.15. **Disconnect Operator**. A flange mounted operator handle must be supplied for each switch or breaker. To prevent false circuit indication, this mechanism must be engaged with the switch or breaker at all times regardless of unit door position. The operator handle must have a conventional up-down motion with the down position as “OFF.” It must be possible to lock this handle in the “OFF” position with up to three 3/8 in. diameter shackle padlocks. The operator handle must be color coded to display red in the “ON” position and black in the “OFF” position.

The operator handle must be interlocked with the unit door so the disconnect cannot be switched to the “ON’ position unless the unit door is closed. It must be possible to defeat this interlock by a deliberate act of an electrician should he desire to observe the operation of the operator handle assembly. This interlock must also prevent opening the unit door unless the disconnect is in the “OFF” position. A defeater for this action must also be provided in the event an electrician must gain access to the unit without interrupting the service.

4.18.4.16. **Starter Units**. Starter units must be completely draw out Type B, sizes as indicated on the plans, so units may be withdrawn without disconnecting any wiring. Units over three space units high may be bolt-in type. A positive guidance system must be provided to assure proper alignment of wedge-shaped power stabs in dead-front openings in vertical power bus. The screw racking mechanism must serve as a mechanical advantage to the operator during unit insertion or removal. Stab-in power terminals must be of a type that will increase contact pressure on short circuits.

Starter units must be rated to withstand short circuits of 65,000 rms symmetrical amp at 480 volts or as noted on the plans.

Starter units must be furnished with start counters.

Provide individual 3-phase monitors that instantly turns off the starter upon phase interruption or loss. Electrical overloads will not be accepted for this function.

4.18.4.17. **Thermal Magnetic Circuit Breakers**. Thermal magnetic circuit breakers must have quick-make, quick-break mechanisms and must visually indicate whether the breaker is closed, open, or tripped.

Breakers must have enough interrupting capacity to properly close against and interrupt instantaneously, without damage, the maximum short circuit current available at the breaker. Interrupting capacity of breakers must beat least 65,000 amps rms symmetrical at 480 V. Provide auxiliary contacts on the circuit breakers where indicated on the plans.

Provide adjustable Long Time, Short Time, and Instantaneous trip settings for breakers 250 Amps and larger.

4.18.4.18. **AC Magnetic Starters–Line Voltage Type**. Motor starters must be across-the-line magnetic type, rated in conformance with NEMA standards, sizes, and horsepower ratings. Starter sizes must be as indicated on the plans. Starter size must be at least NEMA 1.

Across-the-line magnetic starters must be equipped with double-break, silver alloy contacts. All contacts must be replaceable without removing power wiring or removing starter from panel.

Coils must be of molded construction and must operate on 120 V AC. All coils must be replaceable from the front without removing the starter from the panel.

Overload relays must be electronic. Provide Allen Bradley Bulletin 193 E1, Model EE Square D, or approved equal.

All motor starters must be provided with three phase monitors which must disconnect the corresponding load during single phasing conditions.

Provide individual 3-phase monitors that instantly turns off the starter upon phase interruption or loss. Electrical overloads will not be accepted for this function.

4.18.4.19. **Electrical Interlocks**. All starters must be furnished with electrical interlocks as shown on the plans plus two spare normally open and two spare normally closed contacts. Arrangements must be convertible from normally open to normally closed.

4.18.4.20. **Control Transformers**. Provide a control transformer for each motor starter control circuit as indicated on the plans. Control transformers for individual control circuits must be 480–120 volts and must be protected according to code. Size must be as required plus 50VA spare capacity. Primary fuses must be Class “CC.”

4.18.4.21. **AC Magnetic Relays**. The 600-VAC magnetic relays must have convertible contacts and must be rated for 0–600 V, inductive, 60 amp make, 6-amp break, 10 amp continuous, with at least 4 poles and provision to add up to 4 poles making a total of 8.

Contacts must be double-break, silver. Contacts must be convertible from normally open to normally closed or vice versa, without removing the relay from the panel or enclosure. Contacts must be color coded or engraved with respective normally open or closed symbol to indicate status.

Coils must be molded construction, continuous duty rated, and must operate on 120 volts AC.

Terminals must be provided with pressure wire connectors.

4.18.4.22. **Switches**. Selector switches must be non-illuminated. Switches must be 30.5 mm, heavy-duty, oil tight. Switches must have double-break silver contacts. Switches must be maintained contact type unless otherwise indicated on plans. Provide auxiliary contact blocks as indicated on the plans or in the description of operation.

Emergency stop pushbuttons must be snap-type maintained contact, push to open, pull to close, mushroom style switches. Allen Bradley 800 series, Square D, or approved equal.

4.18.4.23. **Push Buttons**. Push buttons must be non-illuminated. They must be 30.5 mm, heavy-duty, oil tight. Contacts rated for at least 10 amps. Push buttons must be normally open or normally closed, as required, momentary contact type, unless otherwise noted on the plans.

4.18.4.24. **Pilot Lights**. Pilot lights must be LED, with push to test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12–130V DC/AC power and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Generally, color caps must be green for “run” and red for “stop” or “off.”

4.18.4.25. **Elapsed Time Meters and Timers**. Elapsed time meters must be time totalizer, non-resettable. They must have a synchronous motor, which must drive a set of digit readout wheels to indicate the total time the unit is energized. Readout must be five-digit including 1/10 digit. Range must be 0 to 9999.9 hr. Voltage rating must be 120 V. Elapsed time meters must be ENM Company Series T50, Square D, or approved equal. Time meters must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the bucket.

Repeat cycle timers must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the bucket. Timer must be Allen Bradley Model 700-HXM66SZ24, Square D or approved equal.

4.18.4.26. **Identification.** A control center identification number nameplate describing section catalog numbers and characteristics must be fastened on the vertical wire trough door of every section. Each control center unit must have its own identification number nameplate giving unit catalog number fastened to the unit saddle near the upper left-hand corner. These nameplates must also have suitable references to factory records for efficient communication with supplier. Each control center unit must also have an engraved Bakelite nameplate fastened to the outside of each unit door.

4.18.4.27. **Wiring**. The motor control center must be wired in conformance with NEMA class and type previously specified and must be furnished to be interconnected with a programmable controller system.

Bore 120 VAC control wiring. Wiring for 24 VDC PLC inputs must be blue. Label wiring in each MCC cubicle.

Mount quick separating, pull apart terminals on lift-out brackets in the units. Label terminals.

4.18.4.28. **Finish**. All painted parts must undergo a phosphatizing pre-painting treatment for rust resistance and good paint bond. Use enamel paint, which must be baked for a durable, hard finish. Paint unit saddles white for easy interior visibility. Paint removeable push button plates, flange mounted operator handles and trim plates, and top horizontal wire trough cover plates a contrasting charcoal gray. Other painted parts must be painted ANSI-49 dark gray.

Plate unpainted parts for resistance to corrosion.

4.18.5. **Execution**.

4.18.5.1. **Field Services**. Perform start-up and testing on the motor control center.

- Test the operation of each motor starter and MCC controls.
- Program the automatic transfer switch and test the operation of the transfer with standby generator.
- The Engineer must have the option to witness start-up and testing.
- Conduits entering the bottom of the MCC must be extended at least 2 in. above surface of equipment pad.

Training: Training must include theory of operation, maintenance and troubleshooting procedures, and programming methods. Start-up, testing activities, and training activities must be conducted on different days.

4.18.5.2. **Installation**. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.

Install motor-control centers on concrete bases. Coordinate size and location of concrete bases.

4.19. **Variable Frequency Controllers**.

4.19.1. **References**. The variable frequency controller (drive) must be designed to meet the following specifications:

- NEC;
- NEMA ICS 3.1–Safety standards for construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems;
- NEMA 250–Enclosures for Electrical Equipment; and
- UL 508A

4.19.2. **Qualifications**.

Manufacturer: Only manufacturers with at least 10 yr. of experience specializing in the design and manufacturing of PWM Drives must be acceptable manufacturers.

Support: Only manufacturers who have maintained factory trained and authorized service facilities within 100 mi. of the project and have a demonstrated record of service for at least the previous 3 yr. must be acceptable manufacturers. Full-time support personnel must be employed by the manufacturer.

Certification: Only manufacturers certified to ISO-9001 Series of Quality Standards with drive products manufactured in an ISO certified facility to assure quality and corrective action procedures have been adhered to must be acceptable manufacturers.

4.19.3. **Products**.

4.19.3.1. **Manufacturers**. Variable Frequency Controller basis of design must be Square D with 3% line reactor or approved equal by Rockwell Automation or Benshaw. The Contractor must be responsible for changes in the work made necessary from the installation of equipment other than the basis of design. Changes must be done without any additional cost to the Department or delay to project completion.

The Variable Frequency Controller with solid-state by-pass starter must be mounted in the MCC as shown on the plans and must meet the full load ampere requirements of the pump motors provided.

The Drive must have manual bypass capability using a solid-state reduced voltage starter where shown. The solid-state reduced voltage starter must be by Square D, or approved equal by Rockwell Automation or Benshaw

Engineering modifications required to meet the specifications and plans must be provided by the manufacturer only. Modifications performed by third parties must not be accepted.

4.19.3.2. **Description**. Only drives suitable for operating the indicated loads must constitute an acceptable product offering. The Drive must conform to requirements of NEMA Specification ICS 3.1. The Drive must fit in the space shown on the plans.

4.19.3.3. **Ratings**.

- The drive must accept an input voltage ±10%.
- For drives greater than 5 HP, the displacement power factor must range from 1.0 and .95 lagging, over the entire speed range.
- **Efficiency**: at least 97% at full load speed.
- **Environmental ratings**:
  - Storage ambient temperature range: -40 C to 70 C (-40 to +158 F)
  - Operating ambient temperature range: 0 C to 40 C (0 to +109 F) without derating.
  - The relative humidity range is 5% to 95% non-condensing.
  - Operating elevation: up to 1000 Meters (3,300 ft) without derating.
- **Output Power Ratings**:
  - The output voltage must be adjustable from 0 to rated motor voltage.

- The output frequency range must be adjustable from 0 to 320Hz.
- The inverter section must produce a pulse width modulated (PWM) waveform using latest generation IGBTs.
- **Sizing**:
  - Loads must be as required to serve the equipment provided.
- Normal duty must provide 110 percent overload capability for up to one minute and 150 percent overload capability for up to three seconds.
- Heavy duty must provide 150 percent overload capability for up to one minute and 200 percent overload capability for up to three seconds.
- Normal duty must be provided unless otherwise indicated.
- **Definitions**:
  - The drive unit must refer to the actual drive that will be mounted within the specified enclosure.
  - The drive system must refer to the drive unit and items specified under drive system options.

4.19.3.4. **Drive Unit Design**.

- Hardware
  - Use diode or fully gated bridge on the input.
  - Use line reactor on all ratings.
- Use switching logic power supply operating from the DC bus.
  - Incorporate phase to phase and phase to ground MOV protection.
  - Use gold plated plug-in connections on printed circuit boards.
  - Microprocessor based inverter logic must be isolated from power circuits.
- Use latest generation IGBT inverter section.
- Inverter section must not require commutation capacitors.
- Employ interface common for all horsepower ratings. Interface must include an LCD digital display, programming keypad and operator key options.
- Main Control Board must be common for all ratings.
  - Control connection must be common for all ratings.
  - Common Node Capacitors available on all frames.
- Control Logic
- Ability to operate a drive with motor disconnected.
- Provide a controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit. Provide annunciation of the fault condition.
  - Use an adjustable PWM carrier frequency within a range of 1-6kHz.
- Provide either Selectable Sensorless Vector or V/Hz modes.
- The drive must be suitable for use on either normal duty or heavy-duty loads. If specified for normal duty, the drive must provide 110 percent overload capability for up to one minute and 150 percent overload capability for up to three seconds. If specified for heavy duty, the drive must provide 150 percent overload capability for up to one minute and 200 percent overload capability for up to three seconds.
  - Provide multiple programmable stop modes including — Ramp, Coast, DC-Brake, Ramp-to-Hold and S-Curve.
  - Provide multiple acceleration and deceleration rates.
  - Make adjustments with the door closed.
  - The drive must have an adjustable output frequency up to 60Hz.
- Power Conditioning
- The drive must be designed to operate on an AC line which may contain line notching and up to 10% harmonic distortion.

- An input isolation transformer must not be required for protection from normal line transients. If line conditions dictate the use of a transformer, the K factor must be 4.0 or less.

4.19.3.5. **Drive Unit Features**.

- Control Module
  - Selectable sensorless vector or V/Hz mode selectable through programming.
  - The sensorless vector mode must use motor nameplate data plus motor operating data such as IR drop, nominal flux current and flux up time.
  - The volts per hertz mode must be programmable for preprogrammed fan curve, straight line, or full custom patterns.
- Current Limit
  - Programmable current limit from 0.1 amps to 150% of drive rated amps.
  - Current limit must be active for all drive states: accelerating, constant speed and decelerating.
  - The drive must employ PI regulation with an adjustable gain for smooth transition in and out of current limit.
- Acceleration/Deceleration
  - Accel/Decel settings must provide separate adjustments to allow either setting to be adjusted from 0 seconds to 3600 sec.
  - A second set of remotely selectable Accel/Decel settings must be accessible through digital inputs.
- Speed Regulation Modes
  - Open Loop
  - Slip Compensation with speed regulation from 0.1 to 0.5%.
  - Process PI control
- Speed Profiles
  - Programming capability must allow the user to produce speed profiles with linear acceleration/deceleration or “S-Curve” profiles that provide changing accel/decel rates.
  - S-Curve profiles must be adjustable.
- Adjustments
  - A digital interface must be used for set-up, operation, and adjustment settings.
  - All adjustments must be stored in nonvolatile memory (EEPROM).
  - No potentiometer adjustments must be required.
  - The drive must provide EEPROM memory for factory default values.
- Process PI Control
  - The drive must incorporate an internal process PI regulator with proportional and integral gain adjustments as well as error inversion and output clamping functions.
  - The feedback must be configurable for normal or square root functions. If the feedback indicates that the process is moving away from the setpoint, the regulator must adjust the drive output until the feedback equals the reference.
  - Process control must be capable of being enabled or disabled with a hardwire input. Transitioning in and out of process control must be capable of being tuned for faster response by preloading the integrator.
  - Protection must be provided for a loss of feedback or reference signal.
- Fault Reset/Run
  - The drive must provide up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart.
  - The automatic mode must not be applicable to a ground fault, shorted output faults and other internal microprocessor faults.
  - The time between restarts must be adjustable from 0.5 sec. to 30 sec.
- Skip Frequencies

- Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance must be provided.
- The set points must have a bandwidth adjustable from 0Hz to 60Hz.

- Run on Power Up: A user programmable restart function must be provided to automatically restart the equipment after restoration of power after an outage.
- Inertial Ride Through:
  - The drive must respond to a loss of AC input power by adjusting the output frequency to create a regenerative situation in the motor.
  - The regenerated energy must recapture the mechanical energy and convert it to electrical energy that must power the drive logic during the power outage.
  - The drive must retain control of the motor during the power outage.
  - The performance must be based upon the amount of system inertia and the length of the outage.
  - The amount of voltage drop required to trigger inertia ride through and the level at which regulation occurs must be adjustable.
  - Inertial Ride Through must be capable of being enabled or disabled vial programming.
- Fault Memory
  - The last 8 fault codes with respective time must be stored in a fault buffer.
  - Information about the drives condition at the time of the last fault such as operating frequency, output current, DC bus voltage and 28 other status conditions must be stored.
  - A power up marker must be provided at each power up time to aid in analyzing fault data.
  - The last eight alarm codes must be stored, without time stamp, for additional troubleshooting reference.
- Overload Protection
  - The drive must provide internal Class 10 or 20 motor overload protection investigated by UL to comply with N.E.C. Article 430.
  - Overload protection must be speed sensitive and adjustable.
  - A viewable parameter must store the overload usage.
- Auto Economizer
  - An auto economizer feature must be available to automatically reduce the output voltage when the drive is operating in an idle mode (drive output current less than programmed motor FLA). The voltage must be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage.
  - When the load increases, the drive must automatically return to normal operation.
- Terminal Blocks: Separate terminal blocks must be provided for control and power wiring.
- Flying Start: The drive must be capable of determining the speed and direction of a spinning motor and adjust its output to “pick-up” the motor at the rotating speed.
- Ride Through: The control logic must be capable of “riding through” a power outage of up to 2 seconds in duration.
- Inputs and Outputs:
  - The standard Input/Output board must consist of both analog and digital I/O.
  - No jumpers or switches must be required to configure inputs and outputs. All functions must be fully programmable.
  - The Input/Output board must have the following analog inputs as standard: at least 2 differentially isolated ±10V (bi-polar) / 20mA, 9 bit plus sign, by common mode noise rejection. One input must be provided from the Primary PLC and one input must be provided from a Secondary PLC. A discrete input must be provided, as detailed below, to allow for selection of one of the above signals to be used for speed reference/control. Analog inputs must be user programmable for a variety of uses including frequency command and process loop input. Analog inputs must be user programmable for function scaling (including invert), offset, signal loss detect and square root.

- The Input/Output board must have the following analog outputs as standard: Quantity 2 differentially isolated ±10V (bi-polar) / 20mA, 9 bit plus sign. One output must be provided to the Primary PLC and one output must be provided to the secondary PLC. The analog output must be user programmable to be proportional to one of fourteen process parameters including output frequency, output current, encoder feedback, output power. Programming must be available to select either absolute or signed values of these parameters.
  - The Input/Output board must have the following digital inputs as standard: Quantity of 6 digital inputs rated 115Vac. All inputs must be individually programmable for functions from a list of 31 that includes Start, Run, Stop, External Fault, Speed Select, Jog and Process PI functions. One input must be provided and programmed to allow for selection of the speed reference/control signal from either the Primary PLC or the Secondary PLC as detailed above.
  - The Input/Output board must have the following digital outputs as standard: Quantity of 2 relay outputs, form C (1 N.O. —1 N.C). Contact output ratings must be 250VAC / 30VDC (2.0 Amps maximum), resistive or inductive. Relays must be programmable to 28 different conditions including Fault, Alarm, At Speed, Drive Ready and PI Excess Error. Timers must be available for each output to control the amount of time, after the occurring event, that the output relay actually changes state.
- Reference Signals: The drive must be capable of using the following input reference signals: Analog inputs, Preset Speeds, Remote Potentiometer, Digital MOP, Human Interface, Communication Module Commands.
- Loss of Reference: In the event of loss of reference signal, the drive must be user programmable to the following: Fault the drive, alarm and maintain last reference, alarm and go to preset speed, alarm and go to minimum speed, alarm and go to maximum speed, or alarm and maintain last output frequency.
  - Metering: The following metering parameter must be accessible through the Human Interface: Output Current in Amps. Output Voltage in Volts, Output Power in kW, Elapsed MWh, DC Bus Voltage, Output Frequency, Last 8 faults, Elapsed Run Time.
- Faults: Fault information must be accessible through the Human Interface. The following faults must be displayed: Power Loss, Undervoltage, Overvoltage, Motor Overload, Heat Sink Over Temperature, Maximum Retries, Phase to Phase and Phase to Ground Faults.

4.19.3.6. **Drive System Options**.

- Enclosure
  - NEMA 1G with washable metal mesh filters on the outside of the enclosure door and over other vented openings
  - Paint: Manufacturer's standard.
  - Top entry and bottom exit for power cables.
- Provide a 6.25 in. x 2 in. door mounted white lamacoid nameplate with black letters (message to be defined during submittal).
  - UL Label for UL panel recognition.
- Drive System Input Circuit Breaker. Provide a door interlocked circuit breaker disconnect.
- Drive input line reactor: Provide a drive input line reactor mounted within the drive system enclosure. The line reactor must meet the following: be iron core with an impedance of 5%, have copper windings, have Class H insulation with 115degree C rise, and be rated for system frequency and voltage.

4.19.3.7. **Manual Bypass with Reduced Voltage Starting**. Provide means to manually switch a single motor from drive control to bypass (across the line) operation with soft start.

Microcomputer must analyze the motor variables and generate control commands that control the motor to reduce the possibility of surges occurring in the system.

- The starting time must be adjustable from 2 to 30 seconds.
- The stopping time must be adjustable from 2 to 120 seconds.
- Provide separate contactors for drive output, RVSS output and total bypass. The total bypass contactor must be used to bypass the RVSS once the motor is up to speed and must be capable of starting and operating the motor if so wired in the field. The contactors must be electrically interlocked.

Provide a door mounted VFD/Bypass selector switch and pilots lights for indication of VFD and Bypass modes of operation.

Provide a Class 10 overload for motor protection while operating in the bypass mode.

Provide a door mounted emergency stop pushbutton with red mushroom head and maintained contacts to deenergize the load in any operating mode.

Implement pump controls according to the schematics shown on the plans; including incorporation of the necessary devices to monitor pump overtemperature, seal failure or RTD's, as required, in coordination with the System Supplier and Pump manufacturer.

4.19.3.8. **Control Power Transformer**. Provide a control power transformer mounted and wired inside of the drive system enclosure to supply enough control power for the VFD, the bypass controller and auxiliary instruments (pressure switches, etc.), as shown on the plans.

The transformer must be rated for drive, bypass, and auxiliary instrument power plus 250VA spare capacity for future customer use.

4.19.3.9. **Common Mode Choke**. Provide a common mode choke at the drive output to help, in conjunction with the proper grounding techniques, reduce or eliminate interference with sensitive electronic equipment or communication devices installed in the same system.

4.19.3.10. **Harmonic Mitigation Techniques**.

- None required, if the VFD is below 100HP.
- Provide VFD with Active Front End for drives 100HP and above.

4.19.3.11. **Auxiliary Relays**. Provide relays for Drive Alarm, Drive Fault and Drive Run. Provide two additional relays to be wired per custom requirements.

The relays must be Allen-Bradley 700HC24A1 relays (2 form C contacts, 2N.O. & 2N.C.), Square D, or approved equal. The relay contacts must be rated for 1I5VAC/30V DC, 5.0 Amp resistive, 5.0 Amp inductive.

- Control Interface
  - The control terminals must be rated for 115V AC.
  - Inputs must be optically isolated from the drive control logic.
- Hand-Off-Auto Selector Switch.
  - Provide a "Hand/Off/Auto" selector switch for start-stop control.
  - The devices must be Allen-Bradley Bulletin 800T pilot devices (30mm, NEMA Type 4/4X/13) mounted on the drive system enclosure door.
- Pilot Lights
  - Provide pilot lights, mounted on the enclosure door, for indication of Run, Stop and Drive Fault.
  - Pilot lights must be LED illumination type with push to test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12–130V DC/AC power, and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Generally, color caps must be red for "run" and green for "stop" or "off." Unused colored shrouds must be provided

to the Engineer to allow for future customization and configuration of pilot light colors as desired or required by the Department.
    - Pilot Lights must be Allen-Bradley Bulletin 800T, Square D, or approved equal. Pilot lights must be NEMA Type or Type 4X as required or approved equal.
- Motor Run Time Meter and Event Counter
    - Provide a digital, non-resettable, door-mounted elapsed time meter.
    - The meter must be electrically interlocked with the Drive Run relay and Bypass contactor (if required) to indicate actual motor operating hours.
    - Provide resettable door mounted event counter.
- Human Interface Module. Provide a door mounted Human Interface Module with integral display, operating keys, and programming keys.
    - The Human Interface must be rated IP66 / UL Type 4X, 12.
    - The display portion must have the following features:
        - The display must be a 7 line by 21 character backlit LCD display with graphics capability.
- The display must show drive operating conditions, adjustments, and fault indications.
- The display must be configured to display in three distinct sections. The first section must be a status display for direction, status, fault/alarm conditions and Auto / Manual mode. The second section must display drive output frequency. The third section must be configurable as a display for either programming menus/information or as a two-line user display for two additional values utilizing scaled units.
    - The Human Interface must provide digital speed control.
    - The keypad must include programming keys, drive operating keys (start, stop, direction, jog and speed control), and numeric keys for direct entry.

4.19.4. **Execution**.

4.19.4.1. **Quality Control**. The vendor's manufacturing facility must be certified to the ISO-9001 series of standards from the International Standards Organization.

Inspect and test incoming material for conformance to the specifications. The manufacturer must employ a vendor certification program to assure the quality of incoming materials.

Inspect and test subassemblies for conformance to specifications.

Dynamically test control printed circuit boards for at least 22 hr. while heat cycled 1 hr. at each temperature setting from 0°C (32°F) to 60°C (140°F).

Subject drives to a Run-In Test with a properly sized motor and operated under cycling load conditions on a dynamometer. The Drive must be subjected to a Run-In Test that brings the Drive to full rated temperature.

Supplied drives must be Qualification Tested and must meet at least minimum testing for shorted output, capacitive coupling, chattering relay and showering arc.

The drives must carry an all-inclusive, 5-yr. parts and labor warranty from the manufacturer, and the warranty must include travel and other miscellaneous expenses.

4.19.4.2. **Start-up Commissioning Services**.

Start-up will be performed at the user's site. The service division of the VFD manufacturer must perform start-up services. VFD manufacture must provide at least 2 days of onsite start-up service for each VFD. The use of third-party supplier start-up personnel is not acceptable.

The installation Contractor must coordinate with the supplier to provide the following.

- A pre-installation meeting with the user to review the following: site ready condition checklist provided by the VFD manufacturer and completed by the installation Contractor, the start-up plan, the start-up schedule, the drives installation requirements.
- Inspect the drives mechanical and electrical devices enclosed.
- Perform a tug test on internal connections within the drive and verify wiring.
- Verify critical mechanical connections for proper torque requirements.
- Verify and adjust mechanical interlocks for permanent location.
- Confirm sectional wiring is connected properly.
- Re-verify control wiring from any external control devices.
- Set up drive internal power supplies and thyristor control circuits.
- Verification of proper phasing from isolation transformer to drive.
- Confirm cabling of drive to motor, isolation transformer and line feed.
- Perform Megger test.
- Apply voltage to the drive and perform operational checks.
- Bump motor and tune drive to the system attributes. (If the load is unable to handle any movement in the reverse direction, the load should be uncoupled before bumping the motor for directional testing.)
- Run the drive motor system throughout the operational range to verify proper performance.

4.19.4.3. **Standard Testing**. The following tests must be carried out in conformance with applicable requirements and specifications of Canadian Standards Association (CSA), Underwriters Laboratories (UL), National Electrical Manufacturers Association (NEMA), European Standard (EN), and International Electrotechnical Commission (IEC).

Functional checks must be performed wherever possible; otherwise, inspection and continuity checks must be made.

Component devices must be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.

Instruments, meters, protective devices, and associated controls must be functionally tested by applying the specified control signals, current, and voltages.

Drives must be inspected for the following:

- Control power failure test;
- Rectifier gating checks;
- Inverter gating checks;
- Link converter tests;
- Machine converter tests; and
- **Load tests**: Drives must be accelerated to the test motor's nominal frequency, under load, decelerated to 10 Hz, then accelerated back to test motors nominal frequency, with a ramp time of approximately ten seconds. This cycle must be repeated continuously for up to one hour. Drives must be tested under load at the test motor's nominal frequency.

4.19.4.4. **Physical Inspection**. The product must meet applicable engineering and workmanship standards and specifications. Verify components against engineering documentation to be present and correctly installed.

Warning plates, isolation barriers, and mechanical interlocks must provide enough safety and isolation for personnel and equipment.

- Warning labels and nameplates must be present and in their specified positions to advise personnel of possible hazards.

- Isolation barriers must be in place within the cabinet. Such barriers protect personnel from touching live components in an area that otherwise does not have power supplied to it.
- Operation of isolation switch handle and door interlocks must be verified. The interlocking prevents the opening of any medium voltage door on a medium voltage cabinet when the isolation switch handle has been moved to the full "ON" position.

Check bus and bus connections for proper clearance, creepage, phasing, and torque.

4.19.4.5. **Witness Testing**. VFD supplier must make the VFD available for witness testing by the Department's representatives, Witness test must include a drive system run test that must consist of operating the variable frequency drive connected to a dynamometer. During the testing of the drive, a demonstration of the operator interface and functionally will be provided as well as demonstration of the operation of the drive. The drive will be tested up to rated horsepower at both steady state and varying speeds. VFD supplier must notify the Engineer 4 weeks in advance of testing date. At the conclusion of testing, the Engineer's representative will convene with the VFD manufacturers Application Engineer or Project Manager to discuss any concerns or issues that arose during the test. Any modifications or changes requested by the Department will be addressed at this meeting.

A review of the electrical and mechanical drawings for the purchased equipment must be done with the Suppliers Application Engineer or Project Manager before commencing the tests. Any questions or clarifications, before commencing the test, will be addressed at this time.

A Certified Test Report must be issued to the Purchaser at the conclusion of the testing.

4.19.4.6. **Warranty**. VFDs and RVSSs must carry an all-inclusive 5-yr. parts and labor warranty from the manufacturer from the date of substantial completion. The warranty must cover all components. The warranty must include travel and other miscellaneous expenses.

4.20. **Control Panels**. As far as the requirements are applicable, provide control panels, control panel components, and control panel modifications performed under this Contract in conformance with this Specification. Unless otherwise indicated, the system integrator should provide the control panels and control panel modifications and they must be complete and include components and wiring as shown on the plans and specifications.

New control panels to be provided under this Contract include, but are not limited to, the following.

- **Station Pump Control Panel (PCP)**. See Specification for additional information.
- **Manufacturer Packaged Pump Controller (PPCs)**. See Specification for additional information.
- Level Control Panel (LCP);
- Sludge Pump Control Panel;
- Control components provided integral to the MCC;
- Test Simulation Panel;
- Local Control Stations; and
- Generator Auxiliary Control.

Work to the Pump Control Panel include, but are not limited to,:

- Development of programming for the PLC, associated OIT/HMI, and communication modems;
- Installation of PLC CPU unit;
- Provision of Ethernet Switch for integration of the Sludge Pump PPC, Strom Water PPC, Generator, ATS, building security, test simulation panel, field I/O into the PLC;
- Provision of 24 VDC Power Supply, UPS unit, and associated batteries;
- Provision and programming of communication modems and integration with the existing RTU; and

- Integration of signals for the pumps, ATS, VFDs, PPCs, Level Controller, and MCC into the PLC and Auxiliary Operation Control Loops.

Requirements of control components identified in this section apply to the entire project and not limited to any particular control panel.

Furnish labor and materials required for providing remote access and I/O communication between the stations as shown on the plans and specifications. Data links are currently provided between the pump station and the existing SCADA. Be responsible for the configuration of the modems and coordination with the telecom provider to ensure that modems are correctly configured and installed to provide transmission and reception of currently existing I/O and all additionally specified I/O.

4.20.1. **Quality Assurance**.

Regulations and Standards.

UL	Underwriters' Laboratories
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
ANSI	American National Standards Institute
IEEE	Institute of Electrical and Electronic Engineers
ISA	Instrument Society of America

The control panel components must be of the most current and proven design. Specifications and plans call attention to certain features but do not purport to cover details entering the design of the control panels. The components provided by the system supplier must be compatible with the functions required and must form a complete working system.

The control panels must be UL listed as a complete assembly in accordance with UL-508A.

Guarantee. Control panels must be guaranteed in writing for defects in materials and workmanship for a period of 2 yr. from the date of substantial completion. The warranty must be comprehensive, and must include parts, labor, travel, and other miscellaneous expenses.

4.20.2. **Submittals**. Submit shop drawings on the control panels in conformance with the requirements of the Instrumentation Section. Shop drawings must be complete and must include a complete bill of material, catalog information, descriptive literature for all components, UPS load studies, wiring diagrams, and panel layout drawings showing dimensions to all devices.

4.20.3. **Products**.

4.20.3.1. **Control Components**. Before being installed or implemented on field equipment, the final modified program must be simulated on the new PLC CPU. Perform complete closed loop checks for I/O to verify complete functionality of the new PLC CPU. Following installation and field testing, the final program must be copied onto the spare PLC CPU which will then be turned over to the Department.

4.20.3.2. **Control Panel Enclosure**. Control panel enclosures must be designed and sized in conformance with the requirements of the Plans and as specified herein.

Where required, additional freestanding enclosures must be NEMA 12, constructed of Type 316 stainless steel with continuously welded seams. Panel must have piano type hinged, overlapping doors with neoprene gasket. Enclosure doors must be equipped with a heavy-duty 3-point latching mechanism operated by a padlocking handle.

Where required, additional wall mounted enclosures must be NEMA 12, constructed of 14-gauge Type 316 stainless steel with continuously welded seams. Panel must have piano type hinged doors with neoprene gasket.

Properly identify control panel components with an engraved nameplate mounted on the inside of the panel. All components not mounted on the front of the panel must be mounted to a subpanel. All wiring must be installed in a neat workmanlike manner and must be grouped, bundled, supported, and routed horizontally and vertically to provide a neat appearance. All wires leaving the panel must be terminated at the terminal strips inside the enclosure. Terminals and wires must be identified in conformance with the Supplier's panel wiring diagrams.

Provide a copper grounding plate inside the control panel for terminating ground wires.

Provide a plastic data pocket inside the control panel.

4.20.3.3. **Enclosure Light Fixture**. Light fixtures must be low profile LED light strip design with the appropriate location and quantity of light fixtures to ensure adequate and full illumination of enclosed components but at least what is required to span across two-thirds width of the panel. Individual light fixtures must have an operating temperature of -22 to 140° Fahrenheit, provide 900 LM illumination, and have 5-watt power draw. The light fixture must be Hoffman Part Number LED24V15 with appropriate power supply for installation in unclassified environments or equivalent by Halo. Fixtures within classified environments must be Hoffman Product Series LEDHL24V or equivalent by Halo.

4.20.3.4. **Enclosure Cooling Fan and Exhaust Grills**. Provide a cooling package for the control panel. The cooling system must be sized to keep the panel temperature below the maximum operating temperature of the equipment housed. A thermostat located in the control panel must control the cooling system. The cooling system must be Hoffman, nVent, or approved equal.

4.20.3.5. **Control Circuit Breakers**. Circuit breakers must be quick-make, quick-break thermal magnetic molded case type individually mounted and identified. Circuit breakers must be Allen-Bradley Bulletin 1492-CB, Omega, or approved equal by Moeller.

4.20.3.6. **120 VAC Uninterruptible Power Supply (UPS)**. Provide 120VAC Tower UPS units for the Pump Control Panel and Sludge Pump Control Panel.

UPS units must be furnished with an alarm contact to indicate when the UPS is operating on battery power and when the UPS has failed or requires maintenance. Alarms must be monitored by the PLC's.

UPS units must have built-in USB port and six built in UPS supported outlets. UPS units must include the optional bypass (PDU) that enables replacing the UPS with a 'hot-swappable' replacement unit with no disruption to connected equipment.

UPS must be sized to power 100% of the full panel load from 1-hour.

The UPS must be Tripp Lite Model BCPRO. No substitutions will be accepted.

4.20.3.7. **24 VDC Uninterruptible Power Supply (UPS) and Batteries**. Provide 24 VDC UPS units as indicated for each group of equipment on the plans and as specified within the individual equipment specifications.

The UPS must be din-rail mounted and furnished with an alarm contact to indicate when the UPS is operating on battery power and when the UPS has failed or requires maintenance. Alarms must be monitored by the Pump Control Panel PLC's.

UPS batteries must be valve regulated, spill proof construction, allowing safe operation in any position. Batteries must have rugged impact resistant ABS case and cover (UL94-HB) and must be UL recognized.

UPS must be rated for 0 Amps to 15 Amps output current at 24 VDC. Batteries must be 12 VDC with 40 Amp-Hours of capacity.

The UPS must be rated for 0°C to 60°C and batteries must be rated for up to 0°C to 50°C.

The UPS must be SITOP 24 VDC UPS, Model 6EP1 931-2EC42 by Siemens with high temperature battery. Batteries must be PS-12400 by Power-Sonic Corporation.

4.20.3.8. **Unmanaged Ethernet Switch**. Provide an unmanaged DIN rail mounted Ethernet switch for installation in the Pump Control Panel to expand the number of available RJ-45 Ethernet ports and allow for integration of the Motor Protection devices and systems, pump electronic modules, building systems, and power monitoring components provided as part of the Automatic Transfer Switch and the MCC into the PLC at the Pump Control Panel. Switches must have the characteristics as shown below:

Table 1
Switch Characteristics

Input Power:	Redundant 10-30 VDC
Humidity:	10% to 95% (Non-Condensing)
Operating & Storage Temperature:	-40°C to 85°C
Mean Time Between Failure:	>2 million hr.
Ports:	Sixteen (16) 10/100BaseTX RJ-45 Ports
Humidity:	10% to 95% (Non-Condensing)
Operating & Storage Temperature:	-40DegC to 85°C

Switch must have IEEE 802.3 Compliance, ESD and Surge Protection on Built-in Ports, and have Autosensing 10/100BaseTX, Duplex, and MDIX. Switch must be provided with a serial configuration port and must have Bi-Color Status LEDs For Link, Speed, Activity & Duplex. Switch must be the N-TRON 316TX-N 16-Port Unmanaged Industrial Ethernet Switch by Redlion, Phoenix Contacts, or approved equal.

4.20.3.9. **Selector Switches**. Supply selector switches that are 30.5mm heavy-duty non-illuminated. Switches must have double-break silver contacts. Switches must be maintained contact type unless otherwise indicated on the plans. Provide auxiliary contact blocks on switches where indicated on the plans or in the description of operation. Provide a gray legend plate for each switch with white marking as indicated on the plans. Selector switches must be Allen-Bradley Bulletin 800T NEMA Type 4, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.10. **Push Buttons**. Push buttons must be 30.5mm, heavy-duty, non-illuminated. Push buttons must have double-break silver contacts. Push buttons must be momentary contact type) color-coded as indicated on the plans. Push buttons must have flush heads. Provide a gray legend plate for each push button with white marking as indicated on the plans. Push buttons must be Allen- Bradley Bulletin 800T, NEMA Type 4.

4.20.3.11. **Pilot Lights**. Pilot lights must be LED illumination type, heavy duty with push-to-test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12-130V DC/AC power and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Pilot lights must have a nominal diameter of 30mm for installation in 30.5mm openings. Unused colored shrouds must be provided to the Department with each control panel to allow for future customization and configuration of pilot light colors as desired or required by the Department.

Pilot Lights must be Allen-Bradley Bulletin 800T, NEMA Type 4/4X and 13 as required, or equivalent by Phoenix Contacts, or approved equal.

Pilot Lights for installation in NFPA defined hazardous locations and classified areas must be Allen-Bradley Bulletin 800H, Type 4, 7, & 9, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.12. **Relays**. Relays must be heavy-duty general-purpose type with 10-amp contacts. Relays must have terminals, which plug-in to a socket, mounted to the inside of the panel enclosure. Terminals for relays with AC coils must be pin type, and terminals for relays with DC coils must be blade type with number of poles as required.

Relay coils must operate on 120 V AC, unless indicated otherwise on the plans. Relays must have an indicator light to indicate the relay coil is energized. Relays must be Idec RR Series or equivalent by Phoenix Contacts.

Main input relays for field devices must be four-pole with outputs assigned as shown on the plans.

Relay inputs, including coil wiring, must be wired through terminal blocks. Outputs must be 24 V to interposing relays. Direct wiring to relays or PLC output cards will not be allowed.

4.20.3.13. **Intrinsically Safe Relays**. Provide intrinsically safe relays as required by applicable electrical codes.

The intrinsically safe relay must be a single channel repeater with a DPDT set of output contacts and must operate on 120 VAC.

The intrinsically safe relays must be Stahl I.S., Isolators Type 9170, or equivalent by Phoenix Contacts.

4.20.3.14. **Intrinsically Safe Barriers**. Provide an intrinsically safe barrier in the control panel as required by applicable electrical codes. The intrinsically safe barriers must be Stahl, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.15. **24 VDC Power Supplies**. The new 24 VDC power supply for the Pump Control Panel must be DIN rail mounted and must be integrated with the new UPS and batteries specified above to provide battery backed up 24VDC to the components within the Pump Control Panel. Power Supply must be capable of receiving 85-132 / 176-264 VAC power (115/230 VAC, Auto Selecting) and providing 24 DC at 10 Amps (240W). Power supply must be rated for operation from -10°C to 60°C and have a mean time between failures of greater than 600,000 hours. 24 VDC power supply for the Pump Control Panel must be Model SDN-10-24-100P by Sola or approved equal.

4.20.3.16. **Single Level Terminal Blocks**. Terminal blocks must be provided in each control panel for terminating field wiring. All terminal blocks must be rated for 600 V AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Terminal blocks for 24VDC inputs must be blue.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-W4, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.17. **Two Level Terminal Blocks**. Terminal blocks must be provided in each control panel for terminating field wiring. All terminal blocks must be rated for 300 V AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-JD3, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.18. **Three Level Terminal Blocks**. Terminal blocks must be provided in each control panel for terminating field wiring. All terminal blocks must be rated for 300 V AC and must be identified with a permanent machine

printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-JT3M, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.19. **Fuse Holders**. Fuse holders must be provided in each control panel as required. All fuse holders must be rated for 300 V AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare fuse holders in the control panel.

Fuse holders must be Allen-Bradley Bulletin 1492-H6, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.20. **Grounding Blocks**. Grounding blocks must be provided in each control panel as required. All grounding blocks must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare grounding blocks in the control panel.

Grounding blocks must be Allen-Bradley Bulletin 1492-JG3, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.21. **Wiring Ducts**. Provide wiring ducts must be provided to manage path of wire and cable inside the enclosures. Provide-back wire retention to trap wires during installation. Ducts should meet a UL 94V-0 Flammability Rating, UL Component Recognized.

4.20.3.22. **120VAC TV Surge Suppressors**. Surge Suppressors must be Allen Bradley, or approved equal with the following features.

- **Max Surge Current**: 40 kA per phase;
- **Housing Rating**: NEMA 4X, non-metallic enclosure;
- **Connection Method**: Parallel, #10 AWG Stranded Wire;
- Provided with thermal fusing;
- **Diagnostics**: Green Status LED, Audible Alarm; and
- UL 1449 2nd Edition Listed.

Mount Surge Suppressor inside control panels.

4.20.3.23. **Alarm Lights**. Alarm lights must be continuous intensity, amber, and sealed in a watertight enclosure. Alarm lights must be Patlite Model PS-24 with a rubber gasket, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.24. **General-Purpose Signal Multiplier**. General-purpose signal multiplier must provide isolated input, two outputs, and power supply. Device must split the input signal into two output signals. The device must have the following features: DIN rail mounted; green power LED to indicate that the supply voltage is present; accepts #14-#24 AWG solid or stranded wiring; requires 18-30VDC power supply; and provides 4-20mA input and two sets of 4-20 mA outputs.

General-purpose signal multiplier must be a Phoenix Contact MCR signal multiplier, or equivalent by Allen Bradley, or approved equal.

4.20.3.25. Industrial Backup PSTN and Leased Line Modem.

- Modem must have the following ports:
  - One Public Switched Telephone Network (PSTN) Port
  - One Leased Line (LL) Port
  - One RS-422/485 Port
  - One RS-232 Port
- Modem must be rated for a temperature range of -13° to +158°F and relative humidity, non-condensing range of 5 to 95%.
- Modem must be designed to operate from 12 to 48 VDC or 12 to 27 VAC power source.
- Modem must provide data rates up to 33.6 kbits/sec. over both PSTN and 2- or 4-wire lease line circuits and data rates up to 115.2 kbits/sec. over the RS-422/485 and RS-232 protocols.
- The Industrial backup PSTN and Leased Line Modem must be Westermo TD-36 485, LV (Low Voltage) equivalent by Data Connect, or approved equal.

4.20.3.26. **Wiring**. See Instrumentation and Control Wiring for supplemental information. Wiring must be stranded copper, 14-gauge, 600-V, Type MTW. Power wiring must be 600-volt, Type MTW, sized as required. Splices are not permitted.

Analog signal wiring must be 18-gauge twisted pairs with foil shield and drain wire, with 600-volt, 90°C insulation. Drain wires must be grounded at one end only.

Isolate wiring and terminal strips by voltage levels to the greatest extent possible.

Wiring must conform to the following color code:

- 120 V, 1 phase: Black, White,
- 24 VDC: Blue,
- 120 VAC Control Wires: Red,
- Interlock control circuits energized from external source: Yellow, and
- Ground Wires: Green.

120 VAC control wires energized from a source external to the control panel power source must be yellow.

Wiring for intrinsically safe circuits must be purple.

All control wiring must be tagged at each end with a legible permanent coded wire-marking sleeve. Sleeves must be white PVC tubing with machine printed black marking. Markings must be in conformance with the wire numbers shown on the control wiring diagrams and must match terminal strip numbers.

In panels where foreign voltages exist, furnish a highly visible warning label outside the panel with the following words:

“WARNING: POWER FROM OTHER SOURCES EXIST IN THIS PANEL.
THEY ARE IDENTIFIED BY YELLOW WIRE COLOR.”

Warning label must be red with white lettering.

4.20.3.27. **Nameplates**. Provide laminated phenolic nameplates on the front of each control panel. Nameplates must be black with white engraved letters. Engraving must be as indicated on the plans. Minimum size of engraving must be 1/4 in.

4.20.3.28. **Spare Parts**. Provide the following spare parts.

- three Selector Switches of each type and model specified and provided.
- five pushbuttons of each type and model specified and provided.

- five pilot lights of each type and model specified and provided.
- three Relays and associated sockets of each type and model specified and provided.
- twenty terminal blocks of each type and model specified and provided.
- five fuses and fuse blocks or holders of each type and model specified and provided.

4.21. **Instrumentation and Communication Wiring**. Provide electrical wiring needed to complete the Instrumentation Systems specified elsewhere in this Item and as shown on the plans.

Work covered by this Section includes, but is not limited to, providing the following:

- Conduit raceways for signal cables;
- Conduit raceways for AC power circuits;
- Signal cables and coaxial cables;
- Branch circuit (power) cables;
- Terminal cabinets, junction and pull boxes;
- Equipment connections; abd
- Category 5e cable (Ethernet & telephone).

Provide raceway systems, cables, and conductors from transmitters and sensing devices, etc. to instrumentation panels, terminal panels, etc. as shown on the plans and specified in instrumentation and control divisions in the specifications or required by the equipment manufacturer.

4.21.1. **Submittals**. Submit shop drawings for the following.

- Terminal cabinets,
- Power cables,
- Signal cables,
- Junction and pull boxes, and
- Category 5 cable.

4.21.2. **Coordination**. Coordinate the work as specified herein with work to be performed and equipment furnished under other divisions of the Specifications to insure a complete and satisfactory control and instrumentation installation.

4.21.3. **Wire and Device Coordination**. Each wire must be labeled and numbered around the wires at each termination of the wires at relays, terminal boards, and other devices. Wire labels must use a legible permanent coded wire-marking sleeve. Sleeves must be white PVC tubing with machine printed black marking. Wire numbers must correspond to wire numbers on the wiring and loop diagrams.

Cabinets and instruments must be identified by the same letter or number combinations used on the elementary wiring diagrams. Identification must be by means of white laminated Bakelite nameplates with 1/4 in. engraved black lettering. The nameplates must be fastened to the device or to the panel just below the device by stainless steel self-tapping screws.

In panels where foreign voltages exist, furnish a highly visible warning label outside the panel with the following words:

“WARNING: FOREIGN VOLTAGES EXIST IN THIS PANEL.
THEY ARE IDENTIFIED BY YELLOW WIRE COLOR.”

Warning label must be red with white lettering.

4.21.4. **Products**.

4.21.4.1. **General**.

- Wiring must be stranded copper.
- Wiring and terminal strips must be isolated by voltage levels to the greatest extent possible.
- Wiring must conform to the following color code.
  - 120 V, 1 phase: Black, White;
  - 24 VDC: Blue;
  - 120 VAC control wires: Red;
  - Interlock control circuits energized from external source: Yellow;
  - Ground wires: Green;
  - 120 VAC control wires energized from a source external to the control panel power source must be yellow; and
  - Intrinsically safe circuits: Purple.

4.21.4.2. **Terminal Cabinets**. Terminals in cabinets, panels, etc. for instrument wiring must be miniature type with captive clamps to facilitate attachment of at least Size 14 AWG, rated for 600 V. Terminals must have continuous marking strips.

4.21.4.3. **Power Cables**. Size power cables as shown on the plans and must be multi-conductor Type TC rated for 600 V and must have crosslinked filled polyethylene or ethylene rubber insulation over Class B stranded copper conductor groups covered with overall polyester film type and with an overall thermoplastic jacket. (Coding must be ICEA, Method 1).

4.21.4.4. **Signal Cables**.

Analog (4-20 mA) signal circuit wiring must be one, twisted shielded pair of 16 AWG instrumentation cable. Each tinned copper conductor, made up of 19 strands of 20 AWG wire must have color coded insulation. Two insulated conductors must be twisted together in an overall aluminum-polyester 100% coverage shield. Must allow for 2 to 50 conductors per cable. Continuously run cables without splices from transmitters to receivers or terminal cabinets. The shielded conductors, along with a stranded, bare 16 AWG drain wire must be rated at 600 V; must bear the UL-TCER label as a recognized component of UR210. Each individual pair must be shielded and the entire multi-conductor cable must also be shielded.

Digital signal cables must be multi-conductor twisted pairs. Conductor sizes and number of pairs must be as shown on the plans or as required by the manufacturer of the signal equipment. Must allow for 2 to 50 conductors per cable. Continuously run cables without splices from transmitters to receivers or terminal cabinets. Cable must be multi-conductor THWN UL-TC-ER wiring.

4.21.4.5. **Communication Cables**. Profibus Cabling must be 600V UL-TC0-ER IS/OS 2118A cabling with gauge size and pair count as required. Modbus RTU cabling must be 3 and 4 wired version as necessary to provide a complete and fully functional system.

Connections between PCs, Modbus devices, Profibus devices, network switches and control network must be made using Category 5e Shielded Twisted Pair solid cable with PVC jacket and shielded RJ-45 connectors, unless otherwise specified. Use shielded Twisted Pair stranded cable for those links that may be subjected to repeated flexing.

Meet the following requirements.

Wiring Type:	Category 5e, TIA/EIA 568C
Impedance:	100 ± 15 Ohms
Conductor Gauge	24 AWG
Cable construction:	4 pair, PVC jacket, solid or stranded conductors.
Connectors:	RJ45, shielded
Frequency:	Up to 1 GHz

Shield:	Copper braid, covering 4 pairs and connectors. Shield connected to external drain wire.

Cat 5E cables must be Data DataTuff Cat 5e 600V AWM-rated Cable by Belden, Square D or approved equal.

Factory terminated cables must be provided, except as listed below. Maximum length is 300 ft., for communication links of greater lengths fiber must be used with appropriate switches and media converters. Field terminated (bulk) cable is only permissible for the following.

- Cables terminated on terminals of field instrument or control devices, and
- Cables that leave a building.

Telephone Cables: Provide Category 5E Cable with RJ-45 connectors for telephone applications where specified.

4.21.5. **Execution**.

4.21.5.1. **Grounding**. Ground wires in conformance per requirements of the electrical specifications.

4.21.5.2. **Installation of Wire and Cable**. Install wire and cable per requirements of electrical specifications.

Shield Grounding: Each signal shield must have only one grounding point which must be located at the source of the signal, (e.g., analog transmitter) unless otherwise recommended by the instrument or equipment manufacturer. Shields must be continuous through cabinets, panels, etc.

Terminations: Terminate wire at both ends of the power and signal cables with pre-insulated solderless spade or ring lugs and in conformance with the requirements of the Control Panel Specification. Spare conductors must be terminated on marked terminal strips or connector pins at each end.

Only pull wires and cables once. Wires and cables which are pulled in one direction and retracted, must be replaced with new wires and cables at no additional cost.

No splices will be permitted.

4.22. **Process Control Strategies**.

4.22.1. **Panel Description**. A pumping system consisting of a motor control center (MCC), variable frequency drives (VFD), station Pump Control Panel (PCP), reduced voltage solids state starters (RVSS), primary transducer, secondary back-up floats, signal booster-duplicator (SB), programmable logic controller (PLC), local control stations, existing remote telemetry unit (RTU), level Control Panel (LCP), manufacturer packaged pump controllers (PPCs), and test simulation panel must be provided for the pumping station.

Manufacturer Packaged Pump Controllers (PPCs): PPCs must be provided by the pump manufacturer. Separate PPCs must be provided for the sludge pump and main storm water pumps: SWP-1 and SWP-2, and Sludge Pump-1 The PPCs must control and monitor the provided pumps. Manufacturer PPC must be provided with integral operator interface terminals and communicate with local hand stations for LOCAL/OFF/AUTO interlocks.

Provide a separate local control station enclosures for SWP-1, SWP-2, and Sludge Pump-1.

Locate the PPCs for the main storm water pumps:SWP-1 and SWP-2, in the station Pump Control Panel (PCP).

Locate Sludge Pump-1 PPC in a separate control panel and required to interface with the PCP and local control station.

Provide a Level Control Panel (LCP) to aggregate and duplicate field analog 4-20 mA and discrete level indications. The LCP must communicate level information to the sludge pump PPC, main storm water pumps PPC, and PLC located in the station PCP.

4.22.2. **Station Pump Control Panel (PCP)**. A station PCP must be provided with a PLC to communicate with:

- Main Storm Water Pump PPC
- Sludge Pump PPC
- Human Machine Interface (HMI)
- SWPS: 1, and 2 VFD/SSRVS
- Level Control Panel
- Generator Auxiliary Panel
- Automatic Transfer Switch
- Building Security and HVAC
- Fire Alarm
- Intrusion Switches
- Existing RTU
- MCC

The PLC must be provided with input/output (I/O) modules to communicate via digital-discrete, analog, ethernet, modbus-TCP as necessary to communicate with the equipment and location. Final determination of equipment and communication protocol must be the responsibility of the systems integrator.

Provide PLC as manufactured by Allen Bradley, Schneider Electric, or approved equal.

The PCP must have primary and backup communications with the pumping system manufacturer PCPs. Primary communication must be high-speed communications via Modbus/CATe. Back-up communications must be hardwired analog and discrete signals. Upon loss of primary communication, the PLC must automatically use hardwired I/O. Evaluation must include but not be limited to evaluating and replacing the enclosure, power supplies, I/O cards, modemed, power supplies, switches, communication cards, networks switches, replays, and applicable appurtenances necessary to meet the requirements of the Contract Documents.

Existing Remote Terminal Unit RTU: The Systems Integrator must evaluate the existing RTU to determine its suitability for reuse. The Systems Integrator must be responsible to expand or modify the existing RTU I/O platform to communicate with the new PCP and the existing TxDOT SCADA system.

4.22.3. **Pump Station Control Panel**. A pumping station control panel (PCP) must be provided in the pumping station control room to house manufacturer packaged pump controllers (PPCs) a programmable logic controller (PLC), human machine interface (HMI) or operator interface terminal (OIT), digital displays, and other associated controls for the pumping station equipment. The PCP must provide automatic control, process, and alarm monitoring for the station Operator Interface

PCP and Sludge Pump Control Panels HMI/OIT's should be 15 in. Harmony GTU, Magelis GTU, or approved equal. The HMI/OIT should be supplied with necessary HMI software, drives, and other development tools to provide a complete and functional system in conformance with the specifications and plans.

The PPC programmable operator interface must be mounted on the pumping station control panel. The sludge pump PPC must be provided a standalone enclosure. The operator interface must be programmed to perform the following functions.

- Display Graphic Screens of the Pumping Station,

- Display Process Variables,
- Display Alarm Messages,
- Display Setpoint Screens,
- Trend Wet Well Levels, and
- Trend Pumping Station Flows.

The operator interface must be a color touch screen, which must be networked to the PLC system via Ethernet.

4.22.3.1. **Programmable Controller Software**. Programmable controller programming and documentation software must be provided to enable a workstation to be used to view, edit, program, document, and communicate with the PPC's and station PLC.

4.22.3.2. **General Systems Requirements**. The complete pumping control system must be provided by the pump manufacturer. The pumping manufacturer must be responsible for coordination and communication to provide a complete and functioning system in conformance with the plans and specifications.

The PPC's must have independent, field adjustable, level control set points for each pump start and stop and alarm notification set points. The PPC must control the pump station using the water level measured by the Primary Level Transducer unless one of the following alarms occurs.

- Low Water Level Alarm is triggered via the Primary Level Transducer analog signal and associated set point within the PPC.
- High Water Level Alarm is triggered via the Primary Level Transducer analog signal and associated set point within the PPC.

If one of the above alarms occurs, the level control for the pump station must switch to operation via the back-up float system. The PPC must continue to use the back-up float system for level monitoring and control until the Primary Level Transducer is re-enabled by pressing the "Reset" pushbutton on the Pump Control Panel.

In the back-up float mode of operation, the VFD must operate at the operator selected speed or full speed if in SSRVS Mode.

If either the Low-Level Float or the High-Level Float are triggered and maintained for set periods of time during any of the operational modes detailed above the PCP must trigger a common alarm and enter the Backup Relay/Float operation mode. In this mode the PPC will start and stop the mains stormwater pumps via hardwired control logic and will no longer use the PLC or Level Transducer for station operation or control.

Backup Relay/Float operation must use hardwired time delay relays and must operate independently of the PPC. This mode of operation extends to failure in the PCP. Backup Relay/Float operation must function as follows:

The PCP must contain a time delay relay for each of the four pumps. Upon initial triggering of the high-level float the time delay relays must be energized. As an individual float is triggered and the associated field configurable delay time relay has elapsed, the PCP must start the pump. The time delays must be initially configured to allow individual, sequential starting of the pumps.

Following deactivation of the high-level float, pumps that were called to run must remain running until the individual float is no longer triggered. Pumps must have an adjustable restart timer applicable in all modes of operation.

- When the low-level Float is triggered, pumps must be called to stopped under all operational modes such as Back-Up Relay/Float, Primary Level transducer, and PPC, operational modes.

- Back-Up Relay Float mode must only be applicable for the main storm water pumps.

Any station alarm can be disabled at the station through the local HMI. The alarm disable function must be password protected so that only designated personnel can disable the station alarms. When there is an alarm present at the station it must be displayed on the OIT screens.

The PPC must have an output that will be energized any time there is an alarm present at the station.

Install 1 Primary Level Transducer to sense the level in the wet well and provide automatic control of the pumps. The Transducer must output a 4-20mA analog signal proportional to the wet well level to the PCP and PLC for level monitoring.

Install Backup Relay/Floats in the wet-well for automatic control of the pumps independent of the PPC.

4.22.3.3. **Pump Motor Controls**. The pump motor controls should include the following.

- A variable frequency drive (VFD) and reduced voltage solid state starter must be provided for each of the main storm water pumps. The VFD will be the primary mode of operation. The Operator must manually select the SSRVS mode of operation at the MCC.
- An embedded VFD and manufacturer provided PPC must be provided for the sludge pump.
- The AUTO position of each pump H/O/A selector switch must be wired to allow for remote starting of the pump via the MCC.
- Each pump H/O/A switch must have an auxiliary normally open contact that must close when the switch is placed in the AUTO position. This contact must be wired to the PPC.
- Each VFD and RVSS must have a run contact that must close when the starter is energized and providing power to the pump motor. This contact must be wired to a run indication light and elapsed time meter on the MCC enclosure, and a run relay located inside the enclosure.
- Each VFD and RVSS must have a fault contact that must be wired as an input to the PPC.
- The run status and fault alarm for each VFD and RVSS must be input to the PPC.
- Lock-out stop push buttons (maintained type) must be on the station PCP enclosure or where shown on the plans. The stop buttons must be wired in series with the pump control circuit so that when a stop button is pushed in, power to the control circuit must be disconnected.

4.22.4. **Description of Operation**. The pumps must be controlled by the individual H/O/A selector switches located on the MCC, PCP and Local Station. The HAND and OFF positions of the H/O/A selector switches provide for manual start/stop control of the pumps. In the HAND position, the pump start sequence must begin. In the OFF position, the pump stop sequence must begin.

When the pump H/O/A switches are in the AUTO position, the pumps must be automatically started and stopped by the PPC in response to the wet well level as follows:

Program level setpoints in main storm water pump PPC for the following levels.

- Wet Well High-Level
- Lead Pump Stop
- Lag 1 Pump Stop
- Lead Pump Start
- Lag 1 Pump Start
- Wet Well Low-Level

Program level setpoints in sludge pump PPC for the following levels.

- Sludge Pump Stop
- Sludge Pump Start

- Wet Well Low-Level

The level setpoints must be adjustable via the operator interface located in the main storm water pump and Sludge Pump PPCs

Program the operator interfaces to enable the Operator to select whether the pumps must be controlled by the primary transducer or secondary back-up floats.

Any Mixed Flow Axial Impeller Pump can be selected as the Lead or Lag in Lead-Lag sequence.

The pump alternation must be based upon selection of the Lead or Lag pumps.

The Operator must select the Lag pump order from the operator interface. Any pump must be able to be assigned to any position in the operational door.

The Operator must select the mode of alternation from the operator interface. The three alternation modes are Lag Pump Alternation, Time Alternation, and Manual Alternation.

4.22.5. **Process Control Strategy**. When the level in the wet well rises to the elevation of the Sludge Pump Start level setpoint, the PPC must start the Sludge Pump. When this level is reached, a start delay timer in the PPC must be started. When this timer times out, the PPC must start the Sludge Pump.

If the Sludge Pump cannot keep up with the influent flow, the level in the wet well must rise to the Lead Main Pump Start level set point. When this level is reached, a start delay timer in the PPC must be started. When this timer times out, the PPC must start the Lag Main Pump. If the level is above the Lead Main Pump Stop level, the Lead Main Pump and Sludge Pump must run continuously.

If the Sludge Pump and Lead Main Pump cannot keep up with the influent flow, the level in the wet well will rise to the LagMain Pump Start level set point. When this level is reached, a start delay timer in the PPC must be started. When this timer times out, the PPC must start the Lag Main Pump. If the level is above the LagMain Pump Stop level, the Lag Main Pump, Lead Main Pump and Sludge Pump must run continuously.

The operating pumps will be lowered to minimum speed beforestarting additional an additional pump. The called pump will be started at minimum speed and the Lead and Lag pump speed will be increased simultaneously to mitigate surges in downstream flow.

When the level in the wet well is pumped down to the Lag Main Pump Stop level set point, the PPC must shut down the Lag Pump at minimum speed.

When the level in the wet well is pumped down to the Lead Main Pump Stop level set point, the PPC must shut down the Lead Pump at minimum speed.

When the level in the wet well is pumped down to the Sludge Pump Stop level set point, the PPC must shut down the Sludge Pump.

For each pump, the current number of starts and current runtime hours must be calculated in the PLC for the current 24-hr. period. These values must roll into yesterday's number of starts and yesterday's runtime hours after the current 24 hr. period expires.

When the PLC senses a loss of power, it will remove the run signal to the pumps after a time delay that is set at the OIT. When the power returns, the pumps will start one at a time. There will be a time delay for each pump start so that the pumps are staggered on a restart. These delay times must be set from the OIT.

When the PLC senses a blip in power, it will remove the run signal to the pumps. After a time, delay that is set at the OIT and the pumps are in the ready state, the pumps will start one at a time. There will be a time

delay for each pump start so that the pumps are staggered on a restart. These delay times must be set from the OIT.

If the level in the wet well is drawn down to the Wet Well Low-Level setpoint, a timer in the PPC must be started. If this timer times out and the Low-Level condition still exists, the PPC must shutdown all pumps. When this occurs, a Wet Well Low-Level alarm message must be displayed on the operator interfaces. This condition must also cause the Back-up floats to take control of the station as previously described.

If the level in the wet well rises to the elevation of the Wet Well High-Level setpoint, a timer in the PPC must be started. If this timer times out and the High-Level condition still exists, a Wet Well High-Level alarm message must be displayed on the operator interfaces.

The PPC's must provide failure monitoring for each pump as follows.

When a pump H/O/A switch is in the AUTO position and the pump gets signal to start, a failure timer in the PLC's must be started. If this timer times out and the pump VFD or across the line starter is not running, a "Pump Failure" alarm message must be displayed on the operator interfaces.

If a pump is taken out of AUTO, or experiences a failure or fault, the PPC's must index the lead/lag assignments of the pumps so that this pump is moved to the LAG position. The failed pump must be locked out of the pump sequence until it is placed back in AUTO or its alarm has been cleared.

The following alarms for each of the pumps must be displayed on the operator interfaces located on the control panel.

- Pump Overload
- Pump Not in Auto
- Pump Fail to Start
- Pump Over Temperature
- Pump Seal Failure
- Power Monitoring
- General Description
- TVSS device must be provided for the Pump Control Panel to protect the system from transient voltages that may occur due to lightning or surges on the incoming power line. Description of Operation:

The TVSS devices must be furnished with a normally open alarm contact. This contact must be wired to the PLC. If a TVSS alarm occurs, this contact must close, and a TVSS Alarm message must be displayed on the operator interfaces.

4.22.6. **Uninterruptible Power Supply (UPS)**. Furnish a UPS with a normally open contact that must close when the UPS is operating on battery power. This contact must be wired to the PLC's. When normal power fails and the UPS is operating on battery power, a timer in the PLC should start. If this timer times out and the UPS is still on battery power, a "UPS on Battery Power" alarm message must be displayed on the operator interfaces located on the pumping station control panel.

Furnish a UPS with a normally open contact that must close when the UPS battery power is low. This contact must be wired to the PLC. If the battery power becomes low, a timer in the PLC must be started. If this timer times out and the UPS battery power is still low, a "UPS Battery Power Low" alarm message must be displayed on the operator interfaces.

Furnish 120V UPS units for the Pump Control Panel and Sludge Pump Control Panel. The units must be sized to provide 1-hr. of operation at full load and provided with alarm contacts to indicated when the UPS is operating on battery pawer and when the UPS has failed or required maintenance. Alarms must be monitored by the PLC.

4.22.7. **Operator Interface**. Mount a programmable operator interface on the control panel to display alarm messages and process values, and to enable the operator to change process setpoints in the PLC.

Whenever an alarm occurs, a corresponding alarm message must be displayed on the operator interface as previously described in the description of operation. If more than one alarm is present, the alarm messages must scroll with each message being displayed for 3 seconds.

An alarm message must remain in the system until its corresponding alarm is cleared.

4.23. **Process Control and Instrumentation for Sludge Pump—Manufacturer Packaged Pump Controller (PPC)**. The pump manufacturer must provide a control panel for the Sludge Pumping System the must interface with the Pump Control Panel. This system will include, but is not limited to, the following.

- Communications gateway for each Pumping System (CPS),
- Pump station controller capable of controlling sludge pumps with integral pumps,
- Remote monitoring equipment compatible with the manufacturer's remote monitoring system,
- Surge protection,
- Automatic Pump Cleaning,
- Pump Blockage,
- Time Based Pump cleaning,
- Modular expansion and configuration,
- Commissioning of the control panel, and
- Site acceptance testing (SAT).

4.23.1. **References**.

- UL 508A and 698A
- NFPA 70 - NEC (2017)
- NFPA 820
- ISA 5.1 and 5.4
- ISA/IEC 62443-4-1
- ISA/IEC 62443-4-2
- IEC 60870–5 104

4.23.2. **Submittals**. Submittals must include, but are not limited to, the following.

- Shop drawings,
- Bill of Material (BOM),
- Wiring diagrams,
- Outline and dimension drawings, and
- Enclosure mounting details.

4.23.3. **Delivery, Storage, and Handling**. Deliver, store, protect and handle products to site under provisions of this Item. Store in a clean, dry space. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

4.23.4. **General requirements**. The Pump System manufacturer must design and build the control panel.

4.23.5. **Installation**. Installation must be in conformance with manufacturer's instructions. Perform electrical work performed full conformance to the requirements of the electrical specifications.

4.23.6. **Warranty**. When installed in conformance with the provisions of this Section and related Sections, the warranty against defects in materials and or workmanship on the control panel must be 7 yr. (84 mo.) from

Completion Substantial. The warranty must be in printed form, included with the product submittal, and previously published as the manufacturer's standard warranty for similar units manufactured.

4.23.7. **Products**.

4.23.7.1. **Monitoring and Control Products**. Pumping System Controller (Nexcon, Miltismart or Approved Equal). The station controller must have the following features, at least:

- Hand-off auto switch for each Pumping System (CPS);
- User configurable liquid level setpoints for CPS activation and deactivation;
- User configurable liquid level alarm setpoints for high level;
- Alternation options include Lead/lag;
- Inputs and outputs;
  - 4 zero-voltdigital inputs
- 4 relay outputs rated at 250V or 30VDC, 5 amps; and
  - 1 analog input 24VDC max
  - 1 analog output 24VDC max.
- Sludge Pump Modules. Provide modules as necessary to provide functionality and communication as described on the plans and specifications.
  - Set power, set speed, and displayed current.
  - Automatic start when the power is turned on.
  - Soft start and stop.
  - Energy minimizer.
  - Pipe flushing at pump cycle start.
  - Automatic pump cleaning
  - Pump blockage
  - Time based pump Cleaning
  - Dry run protection
  - Leakage and overheating protection
  - Motor protection.

The pump control system must be provided with at least the following modules.

- Sludge Pump modules,
- VFD module,
- Backplane supply modules,
- Probe module,
- Digital I/O,
- Analog I/O,
- Station Manager, and
- Security.

The following station optimization features must be pre-configured:

- Fat buildup minimization feature that uses a random lead pump start delay timer. The timer must be initially set to 60 sec.
- A sump and pipe cleaning function that will run the CPS to the snore point based on an operator configurable number of pump cycles. The number of cycles must be initially set to 11.
- The CPS must automatically detect a blockage and automatically clear the blockage. The station controller must monitor the status and annunciate an alarm should the blockage not be cleared.
- The station controller must have an energy minimizer function that minimizes the amount of energy used per pumping cycle.

- Integrated data logger with
  - Capacity for recording up to 4,000 events
  - Ability to download events to a USB storage device
- Monitoring of output current, power level, speed, and motor temperature
- Faults on the controller must be configurable for
  - Acknowledgement Required
  - Three levels of priority
  - Automatically resetting fault
- Human Machine Interface (HMI). A display compatible with the pump station manager and the home screen must display the following parameters:
  - Pump status for each pump including:
  - Pump running.
  - Pump is in the HAND position.
- Pump is in the OFF position.
  - Pump is in the AUTOMATIC position.
  - Pump is available to run.
  - Pump fault
  - Pump alternation active indicator.
  - High inflow control

Information Screen that shows the following information.

- Hours Run counter for each pump:
  - total time today, total time yesterday
  - total time this week
  - total accumulated hours since last commissioning
- Pump Start counter for each pump:
  - pump starts today, pump starts yesterday
  - pump starts this week, total accumulated pump starts
  - power in kW
- I/O Status
  - Digital I/O status
  - Analog I/O status with a value in mA

Ability to configure the controller without a laptop and configure at least the following parameters.

- Set point programming of pump activation/deactivation values and level alarm values
- Enable/Disable level alarms, faults, and historical data recording.
- Configuration of Inputs and Outputs
- Configure station optimization parameters
- Configure communications parameter
- Create or restore backup copies of the pump controller configuration settings
- Factory reset the controller.

Supply a 7 in. touchscreen display may be supplied, instead of, or in conjunction with the keypad display, and must have at least the following features.

- Built in web browser
- Multi-touch screen
- Dual core process @ 8MHz
- 512 MB Flash and 1GB Ram
- Fan-less design

- IP65 front panel
- Power: 12-24VDC @8.5W
- Resolution: 800x480
- Operating temperature: 0-60C

Pumping system gateway:

- Each pump must be equipped with 1 pump gateway which must offer at least following interfaces: 1 x USB, 1 x RS485 1 x Ethernet RJ 45 1 x Display interface, 4 x Digital outputs, 4 x Digital inputs, 1 x Analog input & output.
- It must supply the following pump data.
  - Start and stop commands,
  - Power consumption information,
  - Operating speed,
  - Running status, and
  - Fault information.
- The housing must be isolated according to protection class IP 20 applicable to operate in ambient temperature: -20˚C to +60˚C.
- It must be applicable for 24 V DC Power supply.
- The pump gateway must allow to control of the pump through I/O or Modbus RTU or TCP.
- It must have emergency run relay functionality which secures that the pump will operate when the main controller fails.
- The unit must be tested and approved in conformance with international standards CE, UL, RCM and CSA and be designed and manufactured by the pump supplier.

4.23.7.2. **Level Sensor** (Flygt LTU 801, equivalent by Endress and Hauser, or approved equal). The sump must be equipped with a Multi-Stage Level Sensing device or a Level transmitter designed to detect level of the wastewater for pump control and liquid level display.

The Multi-Stage Level Sensing Device must be PVC injected to seal the unit and prevent any moisture from entering any of the sensor units. Each sensor on the probe must be rotated 90° horizontally from the previous sensor along the probe length to eliminate tracking between sensors. Level sensing probes must be pressure injected with an epoxy resin at final assembly to encapsulate internal components and connections, thereby creating a rigid, sealed, homogeneous unit. Two wires must be included within the length of the probe and must be connected to each other at the bottom of the probe. When the wires are connected to the Pump station Controller, the connection must provide fail-safe monitoring of the probe cable and the probe assembly. The flexible cable used for the Level Sensing Probe must be comprised of PVC or PVC multi-conductor construction with a common oversheath that is water and oil resistant. The multi-conductor cable must be identified with numbering and text along the entire length of the outer sheath at required intervals.

The Level transmitter must measure the relative pressure with a ceramic diaphragm and be approved acc. EN 61000-6-2, EN 61000-6-3, EN 61326-1. It must be insulated > 100 MΩ at 500 V DC and the sensor body must be made of Ryton PPS.

The sensors installed in the sump must be approved for explosive areas according UL Class 1, 2 and 3 Division 1 Group A-D T4/T5/T6.

Cables must be secured to the top of probe bodies by synthetic rubber compression fittings for strain relief. The cable must be rated to physically support the combined weight of the sensor and long enough to reach to reach the cable connection box.

Provide a stainless-steel mounting that includes a wiper device that allows maintenance personnel to clean the level sensing probe when necessary.

4.23.7.3. **Float Switch**. Provide cable float switch suitable for indoor or outdoor installation. It must be capable to operate automatically to indicate tank level, start or stop pumps, or actuate level alarm signals.

The float switch and piping must be submersible. A junction box must be provided near the float to allow for ease of removal and replacement. The junction box must be at least NEMA 4X and float switch must be IP 68 rated. Components must be listed as suitable for the hazardous area classification in which they will be installed. Construction must have material compatible with the application. For floats installed in process areas, do not locate the Junction Box in the wet well or enclosed process area.

Provide proper mounting for the float switch and cable to ensure that the float switch is secured and that there are no obstructions within a tank to prevent the full extension of the cable in either direction. Provide adequately designed 316 stainless-steel pole or all stainless-steel weighted chain and weight for each float to allow for the removal, replacement, and adjustment of the floats without entering in the tank and allow for secure mounting within the tank or process area during operating conditions.

The base bid price must be for a complete float switch system including, but not limited to, sensor, cable, enclosure, power supply, intrinsic safety barrier, signal conditioner, pipe mount clamps, and other hardware and accessories as required by manufacturer for a complete and fully functional system.

Provide, install, program, and calibrate each float switch system in areas shown in the Contract Documents. Ensure that Instruments are tagged and calibrated in conformance with PID diagrams, Instrumentation Layout, and Individual Equipment Specifications.

- Type: Mercury free ball float switch.
- Function and Performance
  - Differential: Switch must activate when the process level rises no more than 4" above the fixed mounting position and deactivates when the level decreases to no more than 4" below the fixed mounting position.
  - Switch Rating: 1 amps at 120 VAC or 100 VA at 120 VDC.
  - Provide NO or NC type contact for fail safe operation.
- Physical
  - Float: 316 Stainless Steel, Teflon or nonstick coating, at least 5-in diameter.
  - Totally encapsulated switch.
  - Cable must be heavy duty, PVC, or equivalent jacketed integral to float.
- Accessories Required:
  - Provide stainless steel hardware.
  - Lead wire must be a waterproof cable of enough length so that no splice of junction box is required in the vault.
  - Provide cast-aluminum weatherproof junction box outside the sump pit with terminals for floats and tapped as required for conduit connections.
- Manufacturer: Siemens Water Technologies, Contegra, or approved equal.

4.23.7.4. **Backup UPS system**. Provide a 24VDC power supply with battery backup capable of running al DC loads for at least 1 hr.

4.23.7.5. **Surge suppression**. Supply a 240VAC or 480VAC three-phase surge suppression device must be installed in line with the supply voltage with the following features:

- Each input must have a nominal AC operating voltage of 240V for 240V supply or 277V for 480V supply
- Meet UL 1449 4th edition requirements
- Meet IEC 61643-11 requirements
- A response time of less than 1 ms
- Nominal discharge current: 20kA 8/20 µs
- Maximum discharge current: 50kA 8/20 µs

- Maximum surge capacity: 60kA 8/20 µs
- Voltage protection rating: 1000V (240V) or 1500V (480V)
- Voltage protection level: 1300V (240V) or 1700V (480V)
- Residual voltage at 10kA (8/20 µs): 1395V
- Operating frequency range: 0-500Hz
- Operating temperature: -104ºF to +185ºF

4.23.7.6. **Hazardous Location Protective Device**. The Hazardous Area Protective Device is intended to protect equipment and personnel in areas where hazardous conditions may be present.

Supply an intrinsically safe device according to the following specifications:

- The intrinsically safe barrier must be panel mounted and designed to protect a ball float inputs and level transducer inputs.
- The barrier must be certified intrinsically safe for use with equipment in installations up to and including Class 1, Zone O.
- The intrinsically safe barrier must have screw terminals for wire connections.
- The intrinsically safe barrier must be protected and current limited according to the requirements of UL Class I (Groups A, B, C & D), Class II (Groups E, F, & G) and Class III certification.
- The device must also be CE and CSA listed for applicable locations and must allow a maximum short circuit current of 10 ma.
- The intrinsically safe barrier must be surface mounted using the mounting flanges on either side of the unit assembly.
- The unit must be fastened with approved screws or bolts in conformance with UL requirements.

4.23.7.7. **Control Panel Construction & Assembly**. Control panels must be manufactured in accordance with the UL 508 standard or UL 698A and must be so constructed for the application of a UL listing label by an approved UL control panel assembly facility.

Install and arrange the control panel wiring must in an organized, efficient manner. Inspect control panel wiring for safety and verified by performing a point-to-point test.

Thoroughly inspect and torque electrical connections in compliance with the UL 508 standard or UL 698A standard. External connections to the control panel must be by way of numbered terminal blocks.

Properly check and load test control panels with power applied. A control panel test log must be supplied with the control panel.

Provide control panels from a UL approved control panel assembly facility with the required labels properly attached.

Control panel enclosure environmental rating: Control panel enclosure rating must be specified in conformance with the project requirements or the plans as either NEMA 12 (painted steel) or 4x (stainless steel).

Wiring requirements:

- Wiring for AC and DC control circuits must be type sis or type MTW stranded copper and must be sized for the applied voltage and current. Unless otherwise noted, control circuit wiring must not be smaller than no. 16 AWG.
- Cable wiring for analog signal circuits must be twisted, shielded pairs of stranded copper conductors that must not be smaller than no. 20 AWG.
- Wiring for special signaling equipment such as communications, digital data, and multiplexed signals must be provided by the equipment supplier.
- Wiring must be numbered and marked at each termination point.
- Terminal blocks for internal or external wiring must be din rail mounted, individual screw compression type terminals with machine printed labels.

Grounding. Properly ground panel enclosure in conformance with the national electrical code and local code requirements.

Each analog signal loop must only have its shield wire connected to ground at a single point for the loop. Shields must be grounded at control panels where signals are input to the receiving device and not at the source of the transmitting device.

Local alarm (flashing light). There must be a flashing alarm light mounted on top of the control panel enclosure for local alarm indication. The flashing alarm light must be supplied according to the following specifications:

- UL recognized for use with UL NEMA type 4x &12 enclosures.
- Shatter resistant Lexan globe, UV Stabilized and flame retardant.
- The flashing alarm light must be by Ingram products, equivalent by Phoenix Contacts, or approved equal.

Electrical transient (surge) protection. Protect electrical and electronic components of the control panel against damage due to electrical transients induced in interconnecting lines from lightning discharges and surges in nearby electrical systems.

The transient surge protector must be rated for 25ka per phase or larger.

Enclosure condensation heater. Provide a 120VAC, 100-W enclosure heater inside the control panel. The heater must be a silicone rubber, insulated strip type enclosure heater. The heater must be Hoffman, Hammond, or approved equal.

4.23.8. **Execution**. Perform installation in conformance with plans, specifications, and manufacturers specifications.

4.23.8.1. **Examination**. A factory trained technician must examine the work area before beginning work and check the following.

- The environment is safe to begin working in.
- All surfaces are ready to receive work.
- All tools are in the proper location and are in good condition.
- Grounding of the system.

4.23.8.2. **Field Quality Control**. A factory trained technician must perform the following field tests.

- Point to point wiring verification,
- Utility power verification,
- Site acceptance testing, and
- System demonstration.

Point to Point I/O Verification. After installation of the pumps and the control panel, a factory trained technician must prepare the I/O checklist. The checklist must include the following.

- All inputs and outputs connected to the control panel;
- All alarms that can be generated by the control panel;
- The technician must follow a test procedure to test I/O and alarms.
  - All digital inputs must be tested from point of origin unless it is unsafe.
  - All digital outputs must be tested by running a simulation test from the controller or by simulating the fault condition.
  - All analog inputs must be tested from the point of origin where possible and by use of a signal generator otherwise.
  - All analog outputs must be tested by running a simulation program or by forcing the output to a value.
- The technician must follow a test procedure to ensure the system operation parameters are met.

Configuration Verification. The factory trained technician must document the settings using a factory provided configuration checklist. Each parameter must be verified before the beginning of testing and then again after testing is completed.

Document the configuration of the pump station manager as well as the IPS gateways.

Save the pump station manager configuration to a factory provided SD card after testing is completed.

4.23.8.3. Factory trained Supervision.

- Procure a factory trained technician to check over equipment before putting the equipment into operation.
- Perform a point-to-point test of wiring.
- Perform a functional test of equipment alarms and controls.

4.23.8.4. Certification of Testing.

- All tests must be performed in the presence of a duly authorized representative of the Department. If the presence is waived, certified results must be provided by the Contractor.
- Written notice of tests must be given two weeks in advance.

4.23.8.5. **Test Equipment**. Provide all test equipment.

4.23.8.6. **Training**. Training must be at least 4 hr. and cover the complete Pumping System and related controls. Instruction material must be provided for four trainees.

4.24. **Pump Control System for Main Storm Water Pump—Manufacturer Packaged Pump Controller (PPC)**. A packaged pump control controller must be provided by the pump manufacturer for the main storm water pumps. The packaged pump controller must be provided as part of the Pump Station Control Panel. The complete system must be coordinated by the pump manufacturer to provide a complete and functioning system.

The work in this Section must include furnishing and placing into operation the monitoring and control panel a pump station with submersible column pumps as shown on the plans.

The controller must alternate the pumps and operate the pumps always at its best efficiency.

4.24.1. **References**. Electrical work must be in accordance with electrical requirements as specified.

- UL 508A and 698A,
- NFPA 70-NEC (2017),

- NFPA 820,
- Canadian Underwriters Laboratory (CUL), and
- ISO 9001 and ISO 140001.

4.24.2. **Submittals**. Submittals must include, but not be limited to, the following.

- Shop drawings,
- Bill of Material (BOM),
- Wiring diagrams,,
- Outline and dimension drawings, and
- Enclosure mounting details.

Delivery, storage, and handling. Deliver, store, protect and handle products to site under provisions of the plans and specifications. Store in a clean, dry space. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

4.24.3. **Qualification requirements**. The manufacturer must provide data on alternate equipment manufacturer's experience. Only manufacturers with 20 or more years of experience who have furnished at least 20 similar lift stations that have been in regular operation not less than 5 yr. will be considered. Evidence of experience and operational data may be required from the manufacturer to determine the suitability and efficiency of the equipment offered.

4.24.4. **Installation**. After installation, a pump station start-up must be performed by the installing Contractor under the supervision of the manufacture's authorized representative. Field service must be provided by an authorized, factory trained representative of the pump manufacturer. Services must include, but not be limited to, inspection of the completed pump station installation to ensure that it has been performed in conformance with the manufacturer's instructions and recommendations, supervision of field-testing and activation of the Pump manufacturer's Warranty. The test must demonstrate to the satisfaction of the Department that the equipment meets specified performance criteria, is properly installed and anchored, and operates smoothly without exceeding the full load amperage rating of the motor. The Contractor must be responsible for coordinating the required field services with the Pump manufacturer.

Perform electrical work in full conformance to the requirements of the electrical specifications and plans.

4.24.5. **Warranty**. When installed in conformance with the provisions of this Section, related Sections, and the supplier's installation manual, the warranty on the Monitoring and Control equipment must be 12 mo. from date of Substantial Completion.

4.24.6. **Products**.

4.24.6.1. **Monitoring and Status**.

- The pump manufacturer must supply a control system designed to monitor and control his pumps. The Monitoring system must be mounted in the cabinet and contain per pump one base unit (BU) acting as a gateway between the Pump and the Central Monitoring and a Central Control Unit (CU). The CU must be able to control up to 10 Pumps.
- Each pump must be connected by just two controls leads to the base unit (BU). The control leads must be part of the motor cable. An additional pilot cable must not be allowed.
- The BU must be able to stop the pump if required via an interlocking relay and it must provide connections for optional measuring modules such as a power meter and other I/O modules.
- The CU must be provided for external access and information exchange with the monitoring system via one single point. The user should be able to connect to the CU via an RJ45 jack to Local PC point to point and Local area network.
- A local operator panel must be possible to connect to the CU via a separate RJ45 socket.

- The CU must have a functionality based on embedded web pages that can be used through a PC or operator panel that allows:
  - A graphical user interface for configuration and analysis via computer and HMI
  - Pump status overview
  - Alarm management
  - Analysis through trend graphs and histograms.
  - External communication with any SCADA via Modbus RTU or Modbus TCP
- The CU must contain the same pump data and logged data stored in each pump electronic module for quick access and redundancy.
- The system must support the service and maintenance policy that applies to the pump by generating service reminders and graphically providing users with an overview of service status that facilitates planning of upcoming service,
- The Cabinet must be equipped with HMI Touch panel for access and interaction with the Monitoring and Control system. The panel should be at least 15 in. in size and able to show color.
- When a pump related alarm is generated, the system must support the user in the form of:
  - Measurement data linked to the specific alarm item for analysis.
- Text information about possible root cause errors.
  - Remedial actions.

4.24.6.2. **Soft Starter (DANFOSS MCD 600, Square D, or Approved Equal)**.

- The soft starter must be provided by the manufacturer in configuration suitable for panel mounting or wall mounting. All power devices and components must be inaccessible during routine maintenance or set-up.
- The manufacturer must be able to provide the soft starter in a packaged NEMA 12 enclosure with fused disconnect, motor overload, remote keypad, and control power transformer.
- The soft starter must use a three-phase thyristor (SCR) bridge consisting of at least two SCRs per phase to control the starting and stopping of standard motors.
- The soft starter must incorporate a “self-cleaning” function to remove debris from the impeller. The cleaning function must consist of forced stopping, reversal and forward runs timed to allow for debris to fall from the impeller. After cleaning cycle is complete, drive must resume to automatic operation.
- The soft starter must provide current-feedback (closed-loop) control for linear acceleration without external feedback independent of motor load or type of application. The gating of the thyristors will be controlled in such a manner to ensure a smooth and stable acceleration ramp.
- The soft starter must operate by modulating the output voltage to maintain a user defined start current. Voltage ramp (“open loop”) and current limiting (voltage clamping) type soft starts are not acceptable.
- The soft starter must use Adaptive Acceleration Control which allows selection of different acceleration and deceleration profiles unique to application needs and be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCR’s.
- The soft start must be designed to operate in an ambient temperature from 0 to 104°F and applicable for following site conditions:
- Storage temperature form -10 to 140°F, with Relative humidity up to 95% at 104°F.
- Designed to operate in altitudes up to 3300 ft.
- Capable to operate without limitation between +10% and –15% of nominal voltage.
- The soft start must automatically adapt for operation at 50 to 60 Hz. Frequency tolerance must be +2% to –5% when starting and between +2% to –5% during steady state operation. A microprocessor controlled thermal protection system must be included which continuously calculates the temperature rise of the motor and soft start. It must also provide phase loss, phase reversal, under load, stall, and jam protection.

- The soft start must be capable of supplying 350% of rated full load current for 30 sec. 10 times per hour at maximum ambient temperature. The manufacturer must supply rating information and PC-based selection tools to determine the appropriate rating of the starter for the specific application. The Contractor must supply the appropriate data from the motor and driven load to the soft starter manufacturer.
- All dialog functions, display units, remote functions, terminal blocks, configuration switches must be accessible on the front of the control module. Exposure to control circuits during routine adjustments is prohibited.
- Digital indication must provide, as least, the following conditions:
  - Soft start status: ready, starting, stopping, run.
- Motor status: Current, Thermal status. Fault status – Shorted SCR trip, Excess start time trip, Overcurrent trip, Motor thermistor trip, Phase imbalance trip, Supply frequency trip, Phase rotation trip, Instantaneous overload trip, Power circuit fault, Undercurrent trip, RS485 communications fault, EEPROM read/write failure. A Graphical LCD user interface must be used to configure the following operating parameters as required:
  - Motor full load amps adjustable from 50 to 130% of the controller rating.
  - Current limitation on starting adjustable from 10 to 550% of motor full load rating.
- Total start time adjustable from 1 to 255 sec.
  - Current limit adjustable from 10 to 550% of nominal motor current.
  - Selectable Torque boost.
- Selection of freewheeling/coasting, soft stop, or DC braking.
- Adjustable soft stop current ramp time from 1 to 100 seconds.
  - Braking torque level adjustable from 30% to 100% effectiveness.
- Selection of Overload Class (2, 10, 10A, 15, 20, 25, or 30) must be integral to built-in motor thermal overload protection.
  - Selectable automatic reset operation.
  - Assignment of controller's inputs and outputs.
  - Activation of phase reversal protection.
  - Reset of motor thermal state.
  - Return to factory default settings.
- Three output relays configurable for, line contactor, Run, Tripped, High current flag, low current flag, Output on, DC brake contactor.

4.24.6.3. **Pump Station Controller**. The pump station controller must provide automatic control of the pumps with an HMI display interface.

- The minimum features available in the pump controller must include:
  - Pump control of up to six pumps; including pump grouping and pump alternation.
  - Intelligent Hand-Off-Auto Control for each pump from the main display keypad as follows:
  - Hand mode (semi-automatic, non-maintained manual mode), the pump switches off at the deactivation set point and then resets to Auto mode for the next pump run cycle.
- Hand mode (fully manual, maintained mode). To pump beyond the off (deactivation) set point, the Hand-Off-Auto button must be held down by the user for failsafe control.
- Level set point adjustment for pump activation, deactivation, and station level alarms.
- Level device inputs must include: 4-20mA analog signals and conductive probes or floats.
- Redundant level device inputs with automatic fault control (input device switching).
- Selectable charge (fill) or discharge (empty) modes.
- Pre-configured station optimization features must include:
- Maximum pumps to run.
  - Maximum starts per hour

- Maximum pump run time.
  - Pump maintenance run function
- Pump alternation modes must include:
  - Standard alternation of pumps
  - Fixed sequence pump control
  - User defined alternation using a (N:1) or (N:M) ratio
  - Alternation based on the most efficient pump
  - Alternation by the number of hours run
- Alternation by the number of starts within a specified time period.
- Pump decommissioning mode to allow one or more pumps to be fully decommissioned.
- Up to six unique user defined profiles of set points must be available to control pumps during specific site conditions or events. Features must include:
  - Automatic profile change based on date and time
- Profile selection option from SCADA (remote control), digital input, logic tag or local keypad
- Locked level alarm function to indicate a level device fault.
- Analog input signal watcher function to monitor analog input values for control and alarm uses.
- Level simulation function for pump station commissioning and general testing.
- A datalogger for user-defined faults and events must include:
  - Recording of up to 50,000 events to internal flash memory
  - Download capability up to 10,000,000 events in the form of a comma delimited file (CSV)
- Three phase supply voltage monitoring and supply fault management for the following conditions:
- Under-voltage, Over-voltage
- Phase fail, Phase rotation
- Monitoring of DC power supply, battery voltage, and internal controller temperature.
- Energy, power, and pump efficiency monitoring:
- kW, kVA, power factor, kWHr, KVAH calculation for each pump
- Pump efficiency calculation (gallons per KWHr) for each pump
- Power supply data (voltage, frequency, and phase angle information)
- Motor fault protection features:
  - 3-phase current monitoring for each pump
  - Over current fault detection
  - Under current fault detection
  - Ground fault detection
  - Current phase imbalance fault
  - Motor insulation resistance failure detection
- Flow measurement: (when enabled by software key)
- Calculated flow by liquid level draws down method.
  - Flow monitoring by inputs from a flow meter (analog input and pulsed signal input)
  - Flow alarms for pumps and total station flow
- VFD speed control function (when enabled by software key)
- Fault handling functions:
  - Pump hold out function
  - Automatic reset function after fault condition is no longer present
- Manual reset of fault (if user intervention of fault reset is required)
- Remote control functions via remote telemetry: (when enabled with software key)
  - Change the operating mode of pumps (hand/off/auto operations)
  - Reset of pump faults and station faults
  - Change pump and alarm set point values
  - Change the operational profile of the pumps

- Security
  - User defined password management for access to programming areas in the controller
  - Automatic data logging of personnel who have entered the programming areas
- Automatic logging of unsuccessful login attempts with a date and time stamp
- Digital input option for controlled access to programming areas
- SD and USB media access ports must be available for the following operations:
  - Firmware upgrades
  - Saving or loading pump controller configuration information
  - Exporting or importing MODBUS and DNP3 points list information
  - Downloading data logs
- Advanced programming functions: (when enabled by software key)
- The pump controller must have the ability to be used with IEC61131-3 and IEC61499 compliant PLC programming languages to enhance or modify existing functionality.
  - Isa Graf software programming and Logic Engine scripting language must be supported.
- The pump controller must include a separate user interface (HMI display) keypad for configuration settings, control operations, and advanced programming. The following parameters must be displayed on the main screen:
- Liquid level in percent, meters, feet, inches, or other custom defined units
  - Set points for pump control and level alarms
  - Pump status (running, stopped or next to run)
- Pump availability indication
- Pump fault indication
  - Three user configurable lines of information to display pump station status and data.
- The main screen must include an INFO button to view the following pump station information:
  - Hours Run counter for each pump and the pump station to include:
    - minutes run for last pump cycle
    - total minutes (hourly)
    - total hours today, total hours yesterday
    - total hours this week, total hours last week
    - total accumulated hours
  - Pump Start counter for each pump and the pump station including:
    - pump starts this hour, pump starts last hour
    - pump starts today, pump starts yesterday
    - pump starts this week, pump starts last week
    - total accumulated pump starts
  - Flow values (when enabled by software key)
    - station inflow rate
    - pump flow rate
    - total station volume
- Overflow data (including overflow start time, duration, estimated volume)
  - Power and Efficiency
- Pump efficiency in gallons or liters per KWHr - or KVAh
  - power in kW, KVA
  - power factor
- Energy accumulators per pump in KWHr and KVAH
  - Insulation resistance value for each pump motor in Ohms
  - I/O Status
    - Digital I/O status and accumulated values
    - Analog I/O status with a value in mA and a scaled value

        - 3-phase voltage, frequency, phase angle, power factor
    - Database viewer function to review statistics and tag data information in real time.
    - Communications information and statistics.
- The main screen must include a FAULT button to view fault information as follows:
    - The fault screen will provide fault details along with a date/time stamp.
    - A fault reset option must be presented to the user.
- The main screen must include a HISTORY button to browse history information as follows:
    - View recorded pump station events along with a date/time stamp
    - The history log must be capable of being filtered to display individual events
- The main screen must include a SETTINGS button to configure the pump controller as follows:
    - Set point programming of pump activation values and level alarm values
- Enable/Disable level alarms, faults, and historical data recording.
    - Configuration of Inputs and Outputs
    - Setup parameters for each type of fault available in the pump controller
    - Set alternation mode for pumps
    - Configure station optimization parameters
    - Configure voltage supply monitoring parameters
    - Configure motor monitoring parameters
    - Configure communications parameters
    - Configure data logging parameters
    - Enable level simulation session
    - Create or restore backup copies of the pump controller configuration settings
    - Restart the pump controller
- The Hardware must have following features:
    - The pump controller inputs and outputs must be modular and must be expandable.
    - Available I/O types must include:
        - Digital Inputs (discrete, voltage free input)
        - Digital Outputs (dry contact type, rated at 240VAC/DC, 5A resistive)
        - Analog Inputs (10bit)
        - Analog Outputs (10bit)
    - Digital Inputs must be configurable based on specific input requirements as follows:
- Pump sensor inputs: Flygt FLS circuit, Conductive Seal, PTC Thermistor (overtemp)
        - Conductive probe sensing for liquid level monitoring)
        - Two (2) High speed counter inputs
    - The pump controller must include the following data communication ports:
        - Two (2) Ethernet ports (10Mbit/s)
        - Two (2) RS232 ports (115kBit/s)
        - Two (2) RS485 ports (115kBit/s)
        - One (1) USB device port
        - One (1) SD card port
- The pump controller must support the following communication types:
    - TCP/IP Ethernet
    - UDP
    - RS232 Serial Data
    - RS485 Serial Data
    - Private radio over RS232
    - PSTN (Dial-up)
    - Wireless LAN
    - Cellular Communications

- It must be able to communicate with following protocols:
  - DNP3 (master & slave, level 2 compliant)
  - Modbus (master & slave) as follows: Modbus TCP, Modbus RTU, Modbus ASCII
- The pump station controller must be designed for following environment and performance:
  - Central Processing Unit Speed: 566MHz
  - Central Processing Unit RAM Size: 256Mbyte
  - Central Processing Unit Flash Memory Size: 64Mbyte
  - Real Time Clock (with battery backup)
  - Working temperature: -10°C to +60°C
  - Storage temperature: -40°C to +90°C
  - Humidity: 5% to 95% (non-condensing)
  - IP Ratings: Controller Base Unit (IP20, NEMA 1), Display Keypad (IP65, NEMA4)

4.24.6.4. **Backup control system** (Multitrode, Goulds, or Approved Equal)

- The backup control equipment must be supplied with the following specifications:
  - The control relay must accept 2 or 3 level inputs from ball floats
  - The following settings must be dip switch programmable from the front panel:
    - Conductive probe sensitivity adjustment.
    - Activation Delays.
- Charge/Discharge selection. (MTR Relay)
    - Level Alarm Output (MTRA and SAFE-TL Relay)
- Overtemp and Seal Condition Detection (SAFE-TL Relay)
  - Mounting and Installation: DIN Rail or 2 x #6 screws Base Mount
- Output Contact Rating: 250VAC, 5 Amps Resistive, 2 Amps Inductive.

4.24.6.5. **Hazardous Location Protective Device (Flygt, Allen Bradley, or Approved Equal)**. The Hazardous Area Protective Device is intended to protect equipment and personnel in areas where hazardous conditions may be present.

- The intrinsically safe device must be supplied according to the following specifications:
  - The intrinsically safe barrier must be panel mounted and designed to protect a multi-sensor conductive probe or ball float inputs.
  - The barrier must be certified intrinsically safe for use with equipment in installations up to and including Class 1 Zone O.
  - The intrinsically safe barrier must have screw terminals for wire connections.
- The intrinsically safe barrier must be protected and current limited according to the requirements of UL Class I (Groups A, B, C & D), Class II (Groups E, F, & G) and Class III certification.
  - The device must also be CE and CSA listed for applicable locations and must allow a maximum short circuit current of 10 ma.
- The intrinsically safe barrier must be surface mounted using the mounting flanges on either side of the unit assembly.
- Fasten the unit with approved screws or bolts in conformance with UL requirements.

4.24.6.6. Control Panel Construction and Assembly.

- General Requirements:
- Install the control panel at a level which cannot be flooded even by storm water.
  - The controller must be installed in the Pump Station Controller.
- Provide a control panel manufactured in accordance with ISO 9000-2001 specifications and constructed for the application of a UL Listing Label by an approved UL Control Panel Assembly Facility.

- Thoroughly inspect electrical connections and torque in compliance with ISO specifications. External connections to the control panel must be made by way of numbered terminal blocks.
- Control Panels must be properly checked and load tested with power applied. A control panel test log must be supplied with the control panel.
- Supply Control Panels from a UL approved control panel assembly facility with of the required labels properly attached.
- Control Panel Enclosure Environmental Rating. Control Panel Enclosure rating must be specified in conformance with the project requirements or the plans as either NEMA 12,
- Control Panel Enclosure Requirements:
  - Enclosure must be sized according to physical and functional device requirements.
  - Enclosure seams must be continuously welded and ground smooth.
  - Enclosure door opening flange trough must exclude liquids and contaminants.
  - Enclosure must include an integral body grounding stud and sub-panel mounting studs and be wall mounted, unless otherwise specified.
  - Enclosure door must have hidden hinges for a clean, aesthetic appearance.
  - Enclosure door opening angle must be standard, full access, 135° opening radius.
  - Enclosure door must be interchangeable and removable by pulling a hinge pin.
  - Enclosure door must have a high-impact thermoplastic data pocket mounted on the inner side of the enclosure door and must have a seamless, foam-in-place, one-piece gasket to provide an oil-tight, dust-tight seal against contaminants.
  - Enclosure must have a three-point latching system with a zinc die-cast handle that is painted with black textured polyester powder paint.
  - Enclosure handles must be capable of being padlocked.
- Steel sub-panel must be white.
- When enclosure cut-outs for instruments and other devices are required, cut, punch, or drill holes and finish with rounded edges.
- **Instrument Location Requirements**:
  - Locate instruments or control devices designated for sub-panel (back) mounting in a manner that will allow for maintenance and adjustment.
  - Instrument mounting height must not exceed 6 ft.-6 in. to the top of the instrument and must not be lower than 3 ft.-0 in. to the bottom of the instrument (unless otherwise specified).
- **Wiring Requirements**:
  - Wiring for AC and DC control circuits must be Type SIS or Type MTW stranded copper and must be sized for the applied voltage and current. Unless otherwise noted, control circuit wiring must not be smaller than No. 16 AWG.
  - Cable wiring for analog signal circuits must be twisted, shielded pairs of stranded copper conductors that must not be smaller than No. 20 AWG.
  - Wiring for special signaling equipment such as communications, digital data, and multiplexed signals must be provided by the equipment supplier.
- Number wiring and mark at each termination point.
  - Terminal blocks for internal or external wiring must be DIN rail mounted with screw compression type terminals and machine printed labels.
- Nameplate Requirements. Nameplates are defined as inscribed, plastic plates mounted above or near a panel face mounted component. Unless otherwise noted, nameplates must be engraved, rigid, laminated plastic with an adhesive back. Nameplate color must be blue with white letters.
- Component Labels are defined as printed, vinyl labels mounted above, below or near a sub-panel (back) mounted component for identification. Printed vinyl labels must be white in color with black letters and an adhesive back.

- **Grounding**: Control Panel enclosure must be properly grounded in conformance with the National Electrical Code and local code requirements.
- Each analog signal loop must have a shield wire connected to ground at a single point for the loop. Shields must be grounded at control panels where signals are input to the receiving device and not at the source of the transmitting device.
- Electrical Transient (Surge) Protection
  - All electrical and electronic components of the Control Panel must be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and surges in nearby electrical systems.
  - The transient surge protector must be rated for 25kA per phase or larger.
- Circuit Breakers
  - Power Circuit Breakers must be thermal magnetic type designed for AC current with an interrupting capacity of at least 15,000 amp.
  - Control Circuit Breakers must be in accordance with section UL 489 with an interrupting capacity of at least 10,000 amp.
- Control Power Transformers: Control Power Transformers required to provide control system and accessory power must be machine tool type control transformers with epoxy encapsulated coils or resin impregnated coils, high quality silicon steel laminations, copper magnet wire, molded terminals, and 55°C rise (Class 10 insulation system).
- Supply Voltage/Phase Monitor:
  - The voltage-phase monitor must continually measure the voltage of each of the three phases of the incoming power to the equipment and provide protection for three phase motors and sensitive electronics.
  - The phase monitor must sense the following conditions: under- and over-voltage, voltage unbalance, phase loss and phase reversal.
- Control Relays:
  - Control relays must be square base type with coil voltage (120VAC, 12VDC or 24VDC).
  - Control relays must be 4PDT (4 Pole, Double Throw) with normally closed/normally open contacts rated at 120VAC, 5 amps minimum.
  - Control relays must include an integrated test button and relay energized flag indicator.
- Full Voltage Magnetic Motor Controller:
  - The motor controller must be a NEMA rated, full voltage, non-reversing, across the line contactor and overload relay combination.
  - The motor overload relay must be an ambient compensated type with inverse-time-current characteristic and must be provided with heaters or sensors in each phase matched to nameplate full load current of the specific motor to which it connects.
- GFCI Convenience Receptacle: There must be a 120VAC, 15 Amp GFCI rated convenience receptacle mounted on the dead front swing door of the control panel. Receptacle circuit must be protected by a thermal magnetic circuit breaker.
- Enclosure Condensation Heater
- Install a 120VAC, 50-watt enclosure heater inside the control panel.
  - The heater must be a silicone rubber, insulated strip type enclosure heater.
  - The heater must be Chromalox Model #SL-B-2-5-55P or approved equal.
- Local Alarm (Flashing Light): There must be a Flashing Alarm Light mounted on top of the control panel enclosure for local alarm indication. The flashing alarm light must be supplied according to the following specifications:
  - UL Recognized for use with UL NEMA Type 12 Enclosures.
  - Shatter Resistant Lexan globe, U.V. Stabilized and Flame Retardant.

The Flashing Alarm Light must be by Ingram Products, equivalent by Phoenix Contacts or approved equal.

4.24.7. **Execution**. Perform installation in conformance with this Item and manufacturer's specifications.

4.24.7.1. **Examination**. A factory trained technician must examine the work area before beginning work and check the following:

- The environment is safe to begin working in.
- All surfaces are ready to receive work.
- All tools are in the proper location and are in good condition.
- The system is grounded.

4.24.7.2. **Field Quality Control**. A factory trained technician must perform the following field tests.

- Point to point wiring verification,
- Utility power verification,
- Site acceptance testing, and
- System demonstration.

Point to Point I/O Verification. After installation of the pumps and the control panel, a factory trained technician must prepare the I/O checklist. The checklist must include the following.

- All inputs and outputs connected to the control panel, and
- All alarms that can be generated by the control panel

The technician must follow a test procedure to test I/O and alarms.

- All digital inputs must be tested from point of origin unless it is unsafe.
- All digital outputs must be tested by running a simulation test from the controller or by simulating the fault condition.
- All analog inputs must be tested from the point of origin where possible and by use of a signal generator otherwise.
- All analog outputs must be tested by running a simulation program or by forcing the output to a value.

The technician must follow a test procedure to ensure the system operation parameters are met.

Configuration Verification. The factory trained technician must document the settings using a factory provided configuration checklist. Each parameter must be verified before the beginning of testing and then again after testing is completed. The configuration of the pump station manager as well as the IPS gateways must be documented. The pump station manager configuration must be saved to a factory provided SD card after testing is completed.

4.24.7.3. **Factory Trained Supervision**. Procure a factory trained technician to check over equipment before putting the equipment into operation. Perform point-to-point testing of the wiring. Perform functional test of the equipment alarms and controls.

4.24.7.4. **Certification of Testing**. Tests must be performed in the presence of a duly authorized representative of the Engineer. If the presence is waived, provide certified results. Written notice of tests must be given two weeks in advance.

4.24.7.5. **Test equipment**. Provide all required test equipment.

4.24.7.6. **Training**. Training must be at least 4 hr. and cover the complete Pumping System and related controls. Instruction material must be provided for at least 4 trainees.

4.25. **I/O List** (Refer to Table Below)

Table 2
I/O Values

Equipment	Description	Type	Low Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #1	Pump Controller Fail	DI	N/A	Pump Controller Fail	Primary Modbus Communication
Storm Water Pump #1	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Primary Modbus Communication
Storm Water Pump #1	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Storm Water Pump #1	Speed Indication	AI	4mA	20mA	Primary Modbus Communication
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Storm Water Pump #1	Pump Running	DI	N/A	Running	Primary Modbus Communication
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #1	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication
Storm Water Pump #1	E-Stop	DI	N/A	Emergency Stopped	Primary Modbus Communication
Storm Water Pump #1	VFD/Bypass	DI	VFD	Bypass	Primary Modbus Communication
Storm Water Pump #1	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water Pump #1	Seal Fail	DI	N/A	Seal Fail	Primary Modbus Communication
Storm Water Pump #1	Overload	DI	N/A	Overload	Primary Modbus Communication
Storm Water Pump #1	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication to SSRV
Storm Water Pump #1	Pump Running	DI	N/A	Running	Primary Modbus Communication to SSRV
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication to SSRV
Storm Water Pump #1	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication to SSRV
Storm Water Pump #1	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication to SSRV
Storm Water Pump #1	Pump Controller Fail	DI	N/A	Pump Controller Fail	Secondary Hardwire Communication
Storm Water Pump #1	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Secondary Hardwire Communication
Storm Water Pump #1	VFD Fault	DI	N/A	VFD Fault	Secondary Hardwire Communication
Storm Water Pump #1	Speed Indication	AI	4mA	20mA	Secondary Hardwire Communication
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Secondary Hardwire Communication

Equipment	Description	Type	Low Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #1	Pump Running	DI	N/A	Running	Secondary Hardwire Communication
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Secondary Hardwire Communication
Storm Water Pump #1	VFD Fail	DI	N/A	VFD Fail	Secondary Hardwire Communication
Storm Water Pump #1	E-Stop	DI	N/A	Emergency Stopped	Secondary Hardwire Communication
Storm Water Pump #1	VFD/Bypass	DI	VFD	Bypass	Secondary Hardwire Communication
Storm Water Pump #1	High Temp	DI	N/A	Motor High Temperature	Secondary Hardwire Communication
Storm Water Pump #1	Seal Fail	DI	N/A	Seal Fail	Secondary Hardwire Communication
Storm Water Pump #1	Overload	DI	N/A	Overload	Secondary Hardwire Communication
Storm Water Pump #1	Out-Of-Service	DI	Available	Out-Of-Service	Secondary Hardwire Communication
PLC	Seal Fail	DO	N/A	Seal Fail	Hardwire
PLC	High Temp	DO	N/A	Motor High Temperature	Hardwire
PLC	Pump Running	DO	N/A	Running	Hardwire
Storm Water Pump #2	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Primary Modbus Communication
Storm Water Pump #2	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Storm Water Pump #2	Speed Indication	AI	4mA	20mA	Primary Modbus Communication
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Storm Water Pump #2	Pump Running	DI	N/A	Running	Primary Modbus Communication
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #2	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication
Storm Water Pump #2	E-Stop	DI	N/A	Emergency Stopped	Primary Modbus Communication
Storm Water Pump #2	VFD/Bypass	DI	VFD	Bypass	Primary Modbus Communication
Storm Water Pump #2	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water Pump #2	Seal Fail	DI	N/A	Seal Fail	Primary Modbus Communication
Storm Water Pump #2	Overload	DI	N/A	Overload	Primary Modbus Communication
Storm Water Pump #2	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication to SSRV
Storm Water Pump #2	Pump Running	DI	N/A	Running	Primary Modbus Communication to SSRV

Equipment	Description	Type	Low Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication to SSRV
Storm Water Pump #2	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication to SSRV
Storm Water Pump #2	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication to SSRV
Storm Water Pump #2	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Secondary Hardwire Communication
Storm Water Pump #2	VFD Fault	DI	N/A	VFD Fault	Secondary Hardwire Communication
Storm Water Pump #2	Speed Indication	AI	4mA	20mA	Secondary Hardwire Communication
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Secondary Hardwire Communication
Storm Water Pump #2	Pump Running	DI	N/A	Running	Secondary Hardwire Communication
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Secondary Hardwire Communication

4.26. **Systems Integrator and Pump Control System General Requirements.**

4.26.1. **Description**. Obtain the services of a subcontractor who will provide a complete integrated Pump Control Systems (PCS) including but not limited to provision and integration of a new Station Pump control Panel, Sludge Pump Control Panel, Level Control Panel, Local control Panels, Signal duplicators, VFD/SSRVS, building security systems, building air conditioning/heat relief system, security systems, fire alarm system, generator, level control instruments, and existing Remote Terminal Unit (RTU) panels, Generator Auxiliary Control Panel, generator field instrumentation and associated control panels, controls coordination at the Pumping Station and electrical subcontractor, programmable controller system hardware and software, and software programming as shown on the plans and as specified in the Specifications.

Plans show general intent and functionality of the control system and is not intended to show required I/O, wiring, etc. The System Supplier is responsible for the design and inclusion of necessary components to ensure a complete and operable system.

The system integrator will provide programming and graphic displays of the new pumping station PLCs, OITs, and the HMI systems, modify the existing RTU. Changes must reflect changes made to the control strategies and monitored signals under this contract. These modifications must incorporate new devices and equipment, in conformance with the plans and Specifications; as well as the integration of new communication links between the PLCs and equipment associated with the new Motor Control Center at the Pumping Station.

SCADA communication. Work with the System Integrator and electrical subcontractor to coordinate with TxDOT to relocate and expand the existing RTU to the proposed building. Existing Station operation status and alarms communication to SCADA must remain online for the duration of the project. Detailed outage requests must be coordinated with and submitted for approval.

This subcontractor will hereafter be referred to as the System Integrator (SI). The SI will have total responsibility for the design, programming, testing, start-up and implementation of the Pump Control Systems, and associated control, status, and alarm functions for Facility.

As referenced above, the SI is responsible for performance and coordination of the PLCs and Control Systems associated with the existing SCADA system and RTU.

The SI should be available for coordination with other equipment suppliers and the existing SCADA radio network for implementation of the required functions of the equipment in the Pump Control Systems.

- The systems integrator will provide necessary junction boxes, panels, transformers, power supplies, relays, terminal blocks, fusing, grounding, and other components required to meet manufacturers' requirements and produce complete and fully functioning systems.
- It is a requirement of these Specifications that the systems integrator be responsible for purchasing pump control equipment consisting of, but not limited to, the following: motor control center, PLC equipment including expansion and modifications of any existing PLC cabinet, SCADA equipment, computer software, and field instruments.
- **Exception**. Subject to the approval of the Department, the Contractor or subcontractor other than the Systems Integrator may be permitted to furnish pump control items requiring complete system integration. The decision by the Department to deny or to permit pump control items to be furnished by parties other than the Systems Integrator will be final, and the Contractor will not be entitled to any claims based upon the decision rendered by the Department.
- Complete Pump Control System integration remains the responsibility of the systems integrator regardless of whether the Systems Integrator furnished the pump control equipment or another party was permitted to furnish some portion of the pump control equipment.
- The systems integrator is responsible for fully understanding operating conditions, limitations, and criteria of existing motors to remain and new motors to be provided under this Contract regardless of whether the motors are being furnished by other parties or are being furnished by the systems integrator. Furthermore, the systems integrator will be responsible for fully integrating motor operations required to provide a fully functioning Pump Control System. Motor operations requiring complete integration include, but are not limited to,
  - Normal starting (VFD Operation, across-the-line starting, etc.)
  - Emergency starting, as applicable
  - Running
  - Normal shutdown
  - Backup Control Operation
  - Communications Failure
  - Emergency shutdown,
  - Alarming and report-back
- As applicable to the Contract, the following components of the pump motors and the motor control center will be fully integrated into the design provided by the systems integrator:
  - VFD’s
  - MCC’s
  - Reduced voltage soft starters
  - Run contactors
  - Bypass contactors
  - Power factor correction capacitors
  - PLC's
  - Uninterruptable power supplies
  - Surge protection devices
  - Other protective devices
  - Timers and relays
- Switches, push buttons, and indicating lights
- SCADA, monitoring devices, and recording devices
- In addition to the main pumping units, other motor-driven devices that require complete integration to be provided by the Systems Integrator include:
  - Air Conditioning/Heat Relief System

  - Security System
  - Fire Protection
  - Generator System/ATS
- Field equipment requiring complete integration by the Systems Integrator includes, but is not limited to: level transmitters, pressure transmitters, limit switches, flow switches, flow meters, differential pressure transmitters, solenoid valves, HVAC controls (thermostats, humidistats, etc.), control systems enclosures, temperature switches, intrusion switches, light switches, beacons, control panels UPS's, ATS, power monitor, MCC, and battery chargers.
- Certain field equipment require integration by the Systems Integrator into multiple systems. The Systems Integrator is responsible for fully integrating field equipment into appropriate systems as required by this Contract.

4.26.2. **Quality Assurance**.

- Regulations, Standards and Publications:
  - UL Underwriters' Laboratories, Inc.
  - NEC National Electrical Code
  - NEMA National Electrical Manufacturers Association
  - ANSI American National Standards Institute
  - IEEE Institute of Electrical and Electronic Engineers
  - ISA Instrument Society of America
- Quality Control:
  - Provide new components of the Pump Control System of the most current and proven design. Components must be suitable for the intended application and installed and wired in strict accordance with the manufacturer's requirements and this specification. The System Supplier must provide necessary junction boxes, panels, transformers, power supplies, relays, terminal blocks, fusing, grounding, and other components required to meet the manufacturer's requirements and produce a complete and functional system.
  - The complete system must comply with Federal, State, Municipal, or other authority's laws, rules, or regulations.
  - All MCCs and control panels, and their components and materials, must bear the label of the Underwriters' Laboratory. All control panels will be UL listed as a complete assembly.

4.26.3. **Submittals**.

- General:
  - Components required to function as a unit must be submitted as a single item; separate submittals of individual components will not be accepted and will be returned to the Contractor as "Rejected" without further review.
  - New items requiring complete integration which are not being furnished by the Systems Integrator, nevertheless, require review and approval from the Systems Integrator.
- In addition to bearing the appropriate General Contractor and subcontractor submittal cover sheet, submittals for such new items must include a statement, signed, and dated by the Systems Integrator, as follows:
  - "Items (or item) included in this submittal are being furnished by parties other than the Systems Integrator. These items have been thoroughly reviewed by the Systems Integrator and have been determined to be in full compliance with the requirements of the Contract. Furthermore, the Systems Integrator has determined the items included in this submittal are fully compatible with other items requiring systems integration including both existing-to-remain items and new items to be provided under this Contract."
- Shop Drawings:
  - Submit required number of detailed shop drawings for equipment being provided for the Pump Control System. Shop drawings must be submitted within 90 days of the date of Notice to Proceed, but only after the required pre-submittal workshop has been conducted.
  - Submit shop drawings in accordance with Item 5 and the General Notes and should be complete, neat, orderly, and indexed. Make separate shop drawing submittals for each major system component.
  - Refer to individual specification sections for specific shop drawing requirements.
- The SI must submit a complete set of engineered drawings for the Local Control Panel, and Programmable Controller system hardware. These engineered drawings must be done by the System Supplier using a CAD system. The drawing size should be 11 in. x 17 in., or as requested. Drawings include, but not be limited to, the following:

- Control panel elevation, details, front and back panel layout, and wiring diagrams showing terminal numbers and interconnecting wiring. The control panel layout drawings must include dimensions for the location of panel-mounted devices.
- Programmable controller system block diagram, power wiring diagrams and I/O wiring diagrams showing terminal numbers and interconnecting wiring.

- Color copies of screens developed for the Operator Interface Terminals along with a flow chart indicating how each screen is accessed.
- Calculations for the Uninterruptible Power Supply.
- Plan to integrate the new I/Os into the existing RTU and existing SCADA communication.
- Drawings must be easily readable with at least 1/8 in. text height.
- Prepare and submit comprehensive wiring diagrams for the instrumentation work performed under this section. Drawings must include the following:
  - Control wiring diagrams and ISA standard loop drawings with terminal numbers and control devices identified. Loop drawings, one per sheet. Provide drawings 8-1/2 in. x 11 in. or 11 in. x 14 in. in size.
  - Drawings must show sizes and locations of equipment and their control locations. Include detailed dimensions of unit locations, elevations, details, door-mounted devices, and front and back panel layout. Include detailed dimensions of conduits, pull boxes, and wiring troughs.
- Wiring diagrams must contain internal and external ladder wiring schematics with identified terminal numbers, relays, and other control devices. Control electrical diagrams must be drawn with circuitry arranged in functional sequence on ladder-type diagrams. Each horizontal line on the ladder diagram should be assigned a number must be written to the left or right of the ladder. Relay coils should be drawn on the right side of the ladder. Show the line numbers on which the relay contacts appear be shown on the right of each coil. A normally closed contact will be designated by drawing a diagonal line through the contact. Timed contacts should be designated by the letter “T” under the line number. Prepare instrument logic diagrams and schematics using ISA 55.1, IEEE 315 and 315A, and NEMA standard symbols and identification letters.
- Submit drawings in a timely manner to allow for engineering review and incorporation of additions or modifications. Provide a list of parts including numbers and quantities.
- Furnish final as-built drawings on diskettes.
- Control panels furnished by the Contractor must include panel layout drawings and associated wiring schematics as defined above.
  - Integrator’s Data and Drawings:
    The Control Systems Integrator must submit at least seven complete sets of the following information for the Engineer's approval:
    - Point-to-point wiring drawings
    - Process loop drawings
    - Dimensional drawings, wiring and piping drawings for field and pipeline-mounted equipment
    - Equipment specification sheets
    - For control panels: fabrication and nameplate legend drawings and internal wiring schematic drawings
    - Systems schematic drawings illustrating components being supplied complete with electrical interconnections
    - Dimensional drawings, wiring and piping drawings for field and pipeline-mounted equipment
  - Equipment specification sheets:
    - For control panels: fabrication and nameplate legend drawings and internal wiring schematic drawings

- Systems schematic drawings illustrating components being supplied complete with electrical interconnection.
- Computer input/output lists and a written description of the control strategy to be applied to the various process areas
- For process computer systems: system block diagram and control room layout drawings

- After approval, furnish seven complete bound sets of the above information plus the following:
  - Individual Operating and Maintenance Manuals
- Bulletins for each piece of equipment furnished.
  - Complete spare parts list for each piece of equipment
  - Calibration sheets
- At least 8 weeks before the factory testing, the Systems Integrator is required to submit color copies of proposed Human Machine Interface (HMI) screens along with a flow chart indicating how each screen is accessed to the Engineer and the Department for approval.
- Installation, Operation and Maintenance Manuals:
  - Submit installation, operation, and maintenance manuals in 3-ring loose- leaf binder. Manuals must be complete, neat, orderly, and indexed. Submit information in accordance with Section 3.
  - Unless directed otherwise, include the following elements in the preliminary and final O&M manuals:
    - Erection and installation sequence and instructions;
    - Exploded view drawings and illustrations with sequence description for assembly and disassembly of equipment;
- Comprehensive parts and materials list for each equipment element indicating manufacturer and manufacturer's identification number; include name, address, and telephone numbers of sales and service offices nearest project site for each major equipment item;
  - Schedules of recommended spare parts to be stocked, including part number, inventory quantity, and ordering information;
- Performance rating and nameplate data for each major system component;
- Procedures for starting, operating, adjusting, calibrating, testing, and shutting down system equipment;
- Emergency operating instructions and troubleshooting guide;
- Schedule of routine maintenance requirements and procedures, and preventative maintenance instructions required to insure satisfactory performance and equipment longevity;
  - Maintenance instructions for extended out-of-service periods;
  - Complete listing of software programming and licensing agreements;
- Complete operator's Supervisor's Manual for the Control System which includes system hardware and software and the "how to's" of the system;
  - Testing reports;
- ISA specification sheets filled out to reflect final field instrument calibration, purchased model number, and any other as-built condition;
  - As-built shop drawings of panels, wiring, instruments, etc.; and
  - All standard O&M manuals for equipment.

4.26.4. **Coordination**.

- The SI will conduct an initial pre-submittal workshop and coordination meeting with the Contractor, Engineer, and Department to review the scope of the project and the project schedule and discuss the Department’s preferences for how the system will be designed to operate.
- A submittal progress meeting will be conducted by the SI at the 50 percent complete stage with the Contractor, Engineer, and Department to discuss progress of the design and questions that may arise.

- Approximately 30 days after the 100% complete submittal is made, the SI will conduct a final submittal review meeting with the Contractor, Engineer, and Department to discuss final comments before system fabrication.
- The SI is responsible for coordinating the compatibility of components and equipment with the Contractor, particularly the pump motors and associated components.
- The Systems Integrator is responsible for coordinating the compatibility of components and equipment used in control systems of this Contract.
- **New Work**: Should the Systems Integrator determine that there is some incompatibility regarding two or more components to be provided under this Contract, they must bring this issue to the Engineer before the 50% complete submittal stage. The Engineer will decide regarding systems integration; the decision will be final.
- Rehabilitation Work: For rehabilitation work utilizing existing components to remain, the Systems Integrator is required to fully develop an understanding of those existing components practicable and incorporate that understanding into the integration of new and existing components. In the event the Systems Integrator determines there is some incompatibility between one or more existing components to remain and 1 or more new components to be provided under this Contract, they must bring this issue to the Engineer's attention before recommissioning existing components and before the fifty percent (50%) complete submittal stage for new components. The Engineer will decide regarding systems integration; the decision will be final.
- To ensure compatibility between instrumentation components and equipment, it is the responsibility of the Systems Integrator to coordinate interface requirements with the existing mechanical and electrical hardware and to furnish and install signal isolation devices as required to provide safe, reliable, and fully functioning control systems.
- The Systems Integrator and the Contractor must investigate each space in the building through which equipment must pass to reach its final location. If necessary, the Systems Integrator is required to ship the components in sections, sized to permit passage through such areas. The Systems Integrator and the Contractor also must investigate space and allocated access (front, rear, side); any subsequent concerns must be brought immediately to the attention of the Engineer.
- The Systems Integrator must coordinate the installation, placing, and location of system components, their connections to the process components, panels, cabinets, and devices as required to complete the work subject to the Engineer's approval.
- As this is an operating pumping station, the pumping facilities must be always fully operational. All work must be coordinated with the Department's personnel.

4.26.5. **Factory Acceptance Test**.

- The SI will conduct a factory acceptance test for the Pump Control System before shipment of the equipment. The factory test will be conducted at the supplier's facility and should demonstrate the control system was designed and performs in conformance with the Specifications and Plans. All equipment furnished for the Pump Control System must be assembled and interwired so that it functions as a complete system for the factory acceptance test.
- The SI must provide necessary equipment and hardware required to conduct the factory test.
- The factory acceptance test must demonstrate the proper operation of control logic in conformance with the Specifications and Plans, and system hardware and software. The Engineer will witness the factory test. Testing must occur within the 48 contiguous states. If testing is not within 2 hr. of the project site, the SI is responsible for the travel expenses of up to two Department representatives to witness the test. Coordinate scheduled dates with required parties.
- A detailed step-by-step test procedure for testing activities is to be delivered to Engineer no less than 60 calendar days before the scheduled start date. Engineer reserves the right to reschedule the start of

the test if a proper, approved, complete test procedure is not available at least six weeks in advance of the scheduled test date.

- Confirm in writing, times, and dates two weeks before a test.
- Perform a walkthrough of equipment supplied. Use checklist provided as part of the test procedure documents to verify presence of required components. Note exceptions. Engineer reserves the right to cancel remaining test activities if items are missing.
- Inspect each enclosure. Demonstrate quality of workmanship, labeling, dressing of cables, conformance of enclosures with drawings. Record comments on test procedure documents.
- Demonstrate basic PLC functions for each PLC including, but not limited to the following:
- The System Integrator must use the new PLC controller in conjunction with the PLC cards, modules, backplanes, signal duplicators, and Ethernet switches specified by the Contract Documents to allow for factory testing of the new PLC programing and simulation of the interaction and communication between the individual system components and the Pump Control panel. The S.I. must provide any additional temporary or special equipment, relays, etc. needed to fully test the system. Following testing the spare equipment must be repackaged for long term storage and turned over to the Department.
- Exercise every I/O point served by the Pump Control Panel PLC modified under this Contract. Include spares. Provide necessary simulation equipment to simulate discrete inputs, discrete outputs, analog inputs, analog outputs, and serial communication. Simulation equipment should be provided with multiple channels to enable testing of several I/O points without need to connect or disconnect for each point.
- Test each analog input at 0, 50%, 100% of full scale by creating proper signal (e.g., 4-20 mA or 1-5 V) using signal sourcing device.
- Provide an appropriate load (light or buzzer) to test each discrete output. LEDs on DO cards are not enough as an indication of proper DO function.
- Provide suitable meter to measure each analog output point at 0, 50 and 100% of full scale. Provide appropriate switches to simulate contact closures to test every digital input point.
    - Demonstrate UPS operation for brief power outage.
- Provide the following documentation:
    - One copy of submittals applicable to the equipment to be tested.
    - One copy of the Plans and Specifications together with addenda and change orders.
    - One master copy of the test procedure.
    - A complete inventory of the equipment to be tested including make, model and serial number.
- Provide use of the following test equipment:
    - Input/Output Test Set: This set must be wired to representative input and output components to allow complete testing of these components.
    - Off-line diagnostic and test programs.
- Maintenance and test equipment including, but not limited to: voltmeter, ammeter, ohmmeter, oscilloscope, electrician's tool set, and special test equipment.

4.26.6. **Record Drawings**.

- Submit required number of record or as-built drawings for the Pump Control System before delivery of any equipment to the site. Provide an as-built drawing in the control panel.
- Following start-up and commissioning of the system, the SI will make necessary changes to the as-built drawings and re-submit required number of final as-built drawings. A final as-built drawing must also be provided in the control panel.

4.26.7. **System Installation, Start-Up, and Commissioning**.

System Installation:

- All field wiring to the equipment furnished by the SI must be performed under the electrical requirements of the Contract by the Electrical Contractor under the supervision of the Pump Control System Supplier.
- The SI will provide onsite supervision and advice to the installing Electrical Contractor to ensure the system is installed in conformance with the specifications and the manufacturer's requirements.
  - Field wiring may be performed by the Systems Integrator directly or may be performed by the electrical subcontractor working under direct supervision of the Systems Integrator.
- The Systems Integrator must provide onsite supervision and advice to the installing electrical sub-contractor to ensure that control systems are installed in conformance with the Specifications and the manufacturers' requirements.
- For the following connections, the Systems Integrator is responsible for ensuring that field wiring for power and signal circuits are done correctly in conformance with best industry practices to ensure satisfactory functioning installations:
  - Between individual existing devices;
  - Between existing devices and proposed control systems;
  - Between multiple proposed control systems; and
  - Within individual proposed control systems
- The Systems Integrator is responsible for ensuring that control systems are installed properly, tested, and fully operational.
- All proposed instrumentation and control systems must be installed, tested, and operating properly before existing systems are taken out of service.

System Start-Up:

- Submit a detailed testing and start-up plan two weeks before start-up for approval and coordinate scheduled dates with required parties. Submit open and closed loop signal test sheets listing possible signals to be tested for review and approval.
- Conduct open loop point to point wire testing in conformance with the approved signal test sheets in the presence of the Engineer. All conduit and wiring must be installed before open loop testing.
- Conduct closed loop testing from field devices to PLC in conformance with the approved closed loop test sheets in the presence of the Engineer. The open and closed loop testing must be on separate days.
  - Start-up the control system by energizing the system equipment and testing the operation of hardware, software, process control logic, and customized software programs.
  - All start-up and testing must be scheduled, performed in an orderly sequence, and conducted in the presence of and to the satisfaction of the Engineer and Owner.
  - Include the following information in the submittals for this section:
    - Loop checkout schedule.
    - Loop checkout procedure including sign-off forms.
- Schedules, procedures, and sign-off forms for other tests specified.
- Supply for use during the field test activities two-way radios and cellular telephones to permit two-way communications by personnel between sites. These phones and radios will be used by the Engineer and the Contractor, as necessary.

  Perform field testing to verify the operation of the Pump Station controls. Field tests are as follows:
  - Loop tests after troubleshooting.
  - Function tests.
  - Integrated system test.
  - Testing will begin after installation of the system components at the site. These must include:
    - PLC's.
    - Instrumentation.
    - Communications equipment required for operation of the system.

        - Other field instruments, panels, switches, termination cabinets, control devices and related interconnections.
    - Begin testing by performing the following steps:
        - Check equipment against shop drawing list.
- Verify that the equipment has been installed in conformance with Contract Documents and manufacturer's directions.
    - Power up the equipment and calibrate power supplies.
    - Load applications software.
    - Run diagnostics to verify error-free operation.
    - Check each signal wire and spares from the field element termination point to the PLC I/O terminal block. Verify end to end continuity of each wire, and that no stray voltage exists on any other wires. Verify that voltage drop through the wire from end to end is within acceptable limits, as specified. Note and correct any deficiencies.
- Verify that each wire label shows proper wire identification, is legible and that the wire designation shown on the loop drawing matches exactly the wire designation shown on the wire label. Wires must be identified at each end, including any intermediate junction points. Note and correct deficiencies.
    - Provide space on the loop drawings and test sheets to hold Engineer and Contractor's signatures and dates for this test.
- Check each loop from the end element to the respective control display. Include instruments, control devices, panels, termination cabinets, input/output cards and other devices in the loop to ensure proper operation and linkage to appropriate HMI displays at station.
- Whenever possible, motion check the final control element through panels and through operator control stations. When not possible to perform a motion check, simulate the motion check at the final control element location.
- Document loop checks and submit to the Engineer. Include the following:
    - Loop number.
    - Loop description.
    - Termination information.
    - Loop drawing reference.
    - Type of tests performed.
    - Date tested.
    - Signature of tester and date.
    - Signature of Engineer and date.
    - Problem description, if any.
- Summarize loops found to contain defective or inoperable equipment on separate sheets and submit to the Engineer.
    - Correct and recheck work performed under this Contract.
- The Engineer will coordinate correction of defective work by others, (e.g., other Contractors not involved in this project) and correction of deficiencies discovered in existing wiring or instrumentation. Perform rechecking as a part of this Contract.
    - Test function of the system. Include a demonstration of the following maintenance and support functions:
        - System status displays and use.
        - Diagnostics.
        - Power fail/restart.
        - PLC alarming under loss of communications, loss of I/O, etc.
- Operation of PLC on UPS backup power without AC power connected. Verify that battery has enough capacity to maintain operation of equipment for at least the period specified.

- Test control functionality, assuring that control schemes and backup schemes work according to descriptions found elsewhere in the Contract Documents
- Document and submit tests to the Engineer. Include the following:
  - Description of function.
  - Test performed.
  - Copies of messages, displays, reports, and trends which verify operation;
  - Signature of tester and date.
  - Signature of Engineer and date.
  - Problem description, if any.
- Schedule any field testing that may affect the station operation through the Engineer on a daily basis.
  - The SI will not perform any testing which may affect TxDOT and station operations without the Engineer's concurrence.
  - Meet the following conditions before the start of any testing:
    - Correct deficiencies noted during in-factory testing and inspections following installation.
    - Keep onsite documentation pertinent to the equipment being tested.
- Keep onsite, labeled, and properly stored, spare parts, expendables, and test equipment pertinent to the equipment being tested.
  - Keep operational field equipment supplied and pertinent to the equipment being tested.
  - Submit Engineer reviewed test schedules and test procedures.
- Re-load PLC'S and OIT's using images supplied by Contractor or Department as appropriate.
  - Installation work is complete and approved.
  - Drawings and Operation and Maintenance manuals are available for review.
- Test procedures and test results will reflect information contained within the various operation and maintenance manuals furnished. Perform no test without the appropriate manuals being followed word-for-word unless approved. Lack of acceptable manuals will be cause for declaring the test to have failed regardless of the actual test results.
- The Engineer will determine the site sequence in which testing will be performed.
- System Commissioning: Supervise the factory representative's calibration for instrumentation and place the complete control system into operation. The commissioning of the system must include the overall calibration and tuning of control loops and sequences to provide stable control of the pumps. The validity of inputs and outputs for the system must be checked and corrected during the system commissioning.
- The SI will provide someone onsite for the length of time necessary for system installation, start-up, and commissioning.

4.26.8. **Final Acceptance Test**.

- Following the commissioning of the Pump Control System, and the issuance of the Certificate of Substantial Completion to the Contractor, conduct aa final acceptance test for a period of 30 consecutive days. This test must be scheduled with the Engineer and will not begin until the SI receives written approval to start. During that time, the system must operate satisfactorily and in compliance with the Specifications. The SI will promptly correct any problems that occur during the final acceptance test and perform retests as necessary to verify proper operation.
- Following the successful completion of the final acceptance test, a certificate of final acceptance will be issued to the System Supplier.

4.26.9. **Expansion of System I/O**.

- The System Supplier must include in their cost for this Contract the modification of an additional 25 system I/O points above and beyond those identified or required for completion of Contract work. This

must include all costs to configure these points within the system including software programming, drawing changes, and field verification.

4.26.10. **System Graphics**. The Systems supplier is responsible for developing graphics for each controlled, monitored, or integrated system to match the look and feel of the existing SCADA graphics. The Systems Integrator must provide color sample graphics for each system to be reviewed and approved.

The graphic screens must be configured in a hierarchical format to facilitate the operator's interface to the process. The hierarchy must consist of a series of graphic screens that provide progressively more detail as the operator navigates through them. Provide a home icon to allow an operator to return to the facility overview display as described herein from any graphic screens. Graphic screens to include, but not be limited to, facility overview display, main displays, secondary displays, data displays, object displays, trend displays, and alarm displays. The Contractor must include the programming and creation of at least 25 graphical screens associated with the facility.

4.26.11. **Additional Software Configuration and Programming**.

- The System Supplier must include in his cost for this Contract four additional man-days of onsite time for software configuration and programming. The Engineer will determine service dates in one day increments and may not be consecutive. This time will be used for changes or additions that may be required after the commissioning of the system. The Supplier's cost for these additional man-days must include software documentation changes and travel related expenses.
- Copies of software licensing and programming requirements must be provided to the Engineer in digital format and printed format also.

4.26.12. **Training**.

- During the final acceptance test, the System Supplier must arrange for the instruction and training of TxDOT personnel in the operational procedures of the system. At the end of the training, operations personnel must have, as determined, enough knowledge to operate the system.

4.27. **Structural**.

4.27.1. **Concrete**. Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." For concrete in slabs, use Class A with Grade 3 aggregate. Place the proposed generator in the required area adjacent of expansion to pump station location, constructing a foundation slab of concrete with rebars.

- Ensure the detailing of concrete reinforcement bars and accessories conforms to the recommendations of the ACI Detailing Manual (ACI 315-80).
- Mix, transport, and place concrete in accordance with ACI 301-84 and Items 420, "Concrete Structures," and 421, "Hydraulic Cement Concrete."
- Provide standard bar chairs and spacers as required to maintain the concrete cover protection specified during rehab procedure.
- Provide 1-No. 4 reinforcement bar x 4.0 ft. at re-entrant corners and around rectangular holes in slabs unless noted otherwise. Place the bars diagonal to the corner with 1 in. clearance from the top and the side of the slab at the corner.
- Provide concrete cover protection for reinforcement bars as follows (see ACI 318 83 Section 7.7 for conditions not noted):
  - Slabs on Grade (Bottom): 3 in.
  - Slabs on Grade (Top): 3/4 in.

4.27.2. **Foundation**. Provide a subgrade under slabs that has a maximum Plasticity Index of 20 and compact in accordance with Section 132.3.D.1, "Ordinary Compaction" of the Item 132, "Embankment." Use a 2 to 4 in. compacted bank sand layer as a level-up for the slab.

4.27.3. **Structural Steel for Wet Well**. Provide structural steel, rolled shapes and plates conforming to AASTM A 36. Ensure structural steel is hot-dipped galvanized, which are to be painted. Provide stainless steel expansion anchors that have a 4:1 safety factor with a minimum working capacity as follows:

Table 3
Expansion Anchor Requirements

Bolt Diameter (in.)	Min. Shear Strength (lb.)	Min. Pull Out Strength (in.)	Min Embedment (in.)
1/2	2080	1380	2 1/4
5/8	2975	1830	2 7/8
3/4	4280	2530	3 3/4
1	6700	4000	4 1/2

Install the expansion anchors in conformance with the manufacturer's recommendations.

Submit a list of material and specifications (AISI, ASTM, etc.) for the anchor components, as well as pull out and shear values attained from tests performed in accordance with ASTM E488 by a certified independent testing laboratory. Include the manufacturer's installation instructions in the submittal.

Detail, fabricate, and erect the structural steel in accordance with AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings," latest edition and amendments, and the AISC "Code of Standard Practice for Steel Buildings and Bridges."

Do not splice structural steel members if not detailed on the plans without the prior approval of the Engineer as to location, type of splice, and connection to be made.

4.27.4. **Wet Well Roof Access Doors**. Provide floor style access doors. Fabricate the frame from 1/4-in. thick extruded aluminum incorporating a continuous concrete anchor. Fabricate the door leaf from 1/4 in. aluminum diamond tread plate, reinforced with aluminum stiffeners designed to withstand a live load of 300 lbs. per sq. ft. Provide a door capable of opening to 90° and locking automatically in that position with a stainless-steel hold open arm. Incorporate an enclosed stainless steel compression spring assist into the hold open arm. Provide a stainless-steel slam lock with a removable handle for securing the door. Provide a vinyl grip handle to release the cover for closing. Provide an aluminum mill finish, with a bituminous coating applied to exterior of the frame where it will meet concrete. Supply a stainless-steel lifting handle, hinges, and fastening hardware. Install as shown on the plans. Warranty the doors against defects in material and workmanship for a period of 10 yr. and supply a copy of the warranty to the Department.

4.27.5. **Construction Dewatering**. Any dewatering required during any phase of construction is the responsibility of the Contractor. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this specification for construction dewatering.

4.28. **Facility Start-Up and Demonstration Period**. When specified in individual sections of these Specifications, upon completion of work for a particular section, the Contractor must furnish at no extra cost to the Department, the necessary manufacturer's engineers, representatives, technicians, skilled labor, and helpers and must perform start-up activities as required. During start-up, the manufacturer's designated personnel is responsible for fully inspecting, testing, calibrating, lubricating, operating, and certifying the equipment for which they are responsible.

When a manufacturer's representative is not required to perform start-up activities for a particular piece of equipment, the Contractor must perform any required start-up activities in strict conformance with the manufacturer's instructions.

If the operation and maintenance manuals specified hereinafter are not available at the time of the start-up, the Contractor must provide one copy of the manufacturer's operating literature for each system or item of equipment. Installation and operating sheets or booklets normally shipped with equipment may be used for this purpose.

Before starting up and operating any and equipment installed in the pumping station, the Contractor must notify the Engineer. All lubrication and starting up of the equipment must be done in the presence of and to the complete satisfaction of authorized representatives of the Department, and in conformance with manufacturer's recommendations.

The Contractor is responsible for scheduling start-up and factory testing activities for a time mutually agreeable with the Engineer and must provide at least one week notice before the desired date. All preparatory work is required to be completed before arrival of the Engineer. Start-up and testing schedule must include the times the Engineer or his representatives are requested to be onsite. Testing may be canceled and rescheduled in the event the Contractor or any of the Contractors representatives are not prepared to start at the time mutually agreed to start time. The Contractor will not be due any additional time or compensation should testing need to be rescheduled. Contractor will be charged for the time lost by testing cancelations and rescheduling at the cost incurred by the Department, which will be deducted as stated in the specifications.

After start-up activities have been completed, the Contractor must coordinate with the Department and Engineer the start of the demonstrational basis for a period of 30 days. Before beginning the 30-day demonstration period, the Contractor must complete the following.

- Shop drawings have been submitted and approved.
- Equipment warranty and certification forms and manufacturer's certifications have been completed and submitted, and witness testing conducted and completed as required.
- Complete start-up activities.
- Submit and get approval for test reports.
- Submit all project photographs must be submitted.
- Submit and get approval for operation and maintenance manuals.
- A final walk-through of the facility will be conducted by the Contractor with the Engineer to generate the punchlist for the project. Provide the Engineer with 4 weeks' notice before the desired date.
- Any items on the punchlist that are designated as requiring completion before the 30-day demonstration period must be completed.
- Any item on the punchlist not designated as requiring completion before the 30-day demonstration period must be completed before the end of the 30-day demonstration period.
- Deliver spare parts to the Engineer and submit signed receipts for the record.
- SCADA communications between the station and the overall SCADA network must be installed and fully operational.
- Thoroughly clean the facility and complete any finishes requiring touchup.

After the above items have been successfully completed, the Engineer will notify the Contractor that they may begin the 30-day demonstration period.

During the 30-day demonstration period, conduct required training for the newly installed equipment. Training activities must be performed separately from manufacturer's start-up activities and must be held on separate days unless approved otherwise. Coordinate schedule of training with the Engineer. Provide at least 2 weeks' notice for each session.

If problems occur during the 30-day demonstration period that are designated to be of significant magnitude, the problems must be satisfactorily corrected, and the 30-day demonstration period will restart from the beginning.

After successful completion of the 30-day demonstration period, required training, punchlist work, and final cleanup, the Contractor will schedule a follow up walkthrough with the Engineer to verify compliance with requirements.

5. PRODUCT SUBSTITUTION PROCEDURES

Options for making product or process selections. Procedures for proposing equivalent products or processes, including pre-approved, pre-qualified, and approved products or processes.

5.1. **Definitions**.

Product: Product does not include machinery and equipment used for production, fabrication, conveying, and erection of the Work. Products may also include existing materials or components designated for reuse.

5.2. **Process**. Any proprietary system or method for installing system components resulting in an integral, functioning part of the work. For this Item, the word "products" includes processes.

5.3. **Selection Options**. Pre-approved products: Construction products of certain manufacturers or suppliers designated in this Item as "pre-approved." The Department maintains a list of pre-approved products. Pre-approved products for this Project are designated as pre-approved in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.

Pre-qualified products: Construction products of certain manufacturers or suppliers designated in Specifications as "pre-qualified." Pre-qualified products for this Project are designated as pre-qualified in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.

Approved products: Construction products of certain manufacturers or suppliers designated in Specifications followed by words "or approved equal." Approval of alternate products not listed in Specifications may be obtained through provisions for product options and substitutions and by following submittal procedures. The procedure for approval of alternate products is not applicable to pre-approved or pre-qualified products.

Product compatibility: To the maximum extent possible, provide products that are of the same type or function from a single manufacturer, make, or source.

Where more than one choice is available, select product that is compatible with other products already selected, specified, or in use by the Department.

5.4. **Contractor's Responsibility**. Responsibility related to product options and substitutions is defined in the specifications.

Furnish information the Engineer deems necessary to judge equivalency of alternate product.

Pay for laboratory testing, as well as any other review or examination costs, needed to establish equivalency between products to obtain information upon which the Engineer can base a decision.

If the Engineer determines alternate product is not equal to that named in the specifications, furnish one of the specified products.

5.5. **Department Review**. Use alternate products only when approved in writing. The Engineer's determination regarding acceptance of proposed alternate product is final.

Alternate products may be accepted if the Engineer judges the products to be equivalent to specified product or to offer substantial benefit.

5.6. **Substitution Procedure**. Collect and assemble technical information applicable to the proposed product to aid in determining equivalency as related to the approved product specified.

Submit a written request for a construction product to be considered as an alternate product.

Submit product information after the effective date of the Contract and within the time allowed for substitution submittals. After the submittal period has expired, requests for alternate products will be considered only when the specified product becomes unavailable because of conditions beyond the Contractor's control.

Submit five copies of each request for alternate product approval. Include the following information:

- Complete data substantiating compliance of proposed substitution with the Contract.
- For Products:
  - Product identification, including manufacturer's name and address.
  - Manufacturer's literature with product description, performance and test data, and reference standards.
  - Samples, as applicable.
- Name and address of similar projects on which product was used and date of installation. Include names of Owner, design consultant, and installing Contractor.
- For Construction Methods.
  - Detailed description of proposed method.
  - Plans illustrating methods.
- Itemized comparison of proposed substitution with product or method specified.
- Data relating to changes in the Construction Schedule.
- Relation to separate contracts, if any.
- Accurate cost data on proposed substitution in comparison with product or method specified.
- Other information requested.

Approved alternate products will be subject to the same review process as the specified product would have been for Shop Drawings, Product Data, and Samples.

6. BASIC PRODUCT REQUIREMENTS

Requirements for transportation, delivery, handling, and storage of products.

6.1. **Products**. Does not include machinery and equipment used for preparation, fabrication, conveying and erection of the work. Products may also include existing materials or components designated for reuse.

When the plans and specifications require that installation of work, comply with manufacturer's printed instructions, obtain, and distribute copies of such instructions to parties involved in installation, including 2 copies to the Engineer. Maintain one set of complete instructions at jobsite during installation until completion.

Provide products from the fewest number of manufacturers as practical, to simplify spare parts inventory and to allow for maximum interchangeability of components. For multiple components of the same size, type, or application, use the same make and model of component throughout the work.

6.2. **Transportation**. Arrange for transportation, delivery, and handling of products required for timely completion of the work. Transport and handle products in conformance with the manufacturer's instructions. Consign and address shipping documents to proper party giving name of the Project and its complete street address. Shipments are to be delivered to the Contractor.

6.3. **Delivery**. Arrange deliveries of products to accommodate short-term site completion schedules and in ample time to facilitate inspection before installation. Avoid deliveries that cause lengthy storage or overburden of limited storage space. Coordinate deliveries to avoid conflict with the work and conditions at the site and to accommodate the following.

- Work of other Contractors or the Department.
- Limitations of storage space.
- Availability of equipment and personnel for handling products.
- The Department's use of premises.
- Products delivered to the site are in the manufacturer's original, unopened, labeled containers. Immediately upon delivery, inspect shipment to assure:
- Product complies with requirements of the Contract.
- Quantities are correct.
- Containers and packages are intact; labels are legible.
- Products are properly protected and undamaged.

6.4. **Product Handling**. Coordinate off-loading of products delivered to the site. If necessary, during construction, move and relocate stored products at no additional cost. Provide equipment and personnel necessary to handle products, including those provided by the Department, by methods to prevent damage to products or packaging. Provide additional protection during handling as necessary to prevent breaking, scraping, marring, or otherwise damaging products or surrounding areas. Handle products in conformance with manufacturer's recommendations.

6.5. **Storage of Products**. Store and protect products in conformance with manufacturer's recommendations and requirements of these Specifications.

Make necessary provisions for safe storage of products. Place products to prevent damage to any part of the work or existing facilities and to maintain free access at all times to all parts of the work and to utility service company installations in the vicinity of the work. Keep products neatly and compactly stored in locations that will cause minimum inconvenience to other Contractors, public travel, adjoining owners, tenants, and occupants. Arrange storage in a manner to provide easy access for inspection.

Provide offsite storage and protection when onsite storage is not adequate. Provide addresses of, and access to, off-site storage locations for inspection.

Do not use lawns, grass plots, or other private property for storage purposes without written permission of owner or other person in possession or control of premises.

Protect stored products against loss or damage.

Neatly, safely, and compactly stack products delivered and stored along the line of the work to avoid inconvenience and damage to property owners and the general public and maintain at least 3 ft. clearance around fire hydrants. Keep public, private driveways, and street crossings open.

Repair or replace damaged lawns, sidewalks, streets, or other improvements to the satisfaction of the Engineer. The total length that products may be distributed along route of construction at one time is 1000 ft., unless otherwise approved in writing.

7. STARTING SYSTEMS

This Section includes starting systems, demonstration and instructions, and testing, adjusting, and balancing.

7.1. **Preparation**. Coordinate schedule for start-up of various equipment and systems.

Notify Engineer 7 days before start-up of each item.

Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions which may cause damage.

Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.

Verify wiring and support components for equipment are complete and tested.

Execute start-up under the Contractor's supervision in conformance with the manufacturer's instructions.

When specified in specification sections, require the manufacturer to provide an authorized representative to be present at the site to inspect, check, and approve equipment or the system installation before start-up, and to supervise placing equipment or the system in operation.

Submit a written report that the equipment or system has been properly installed and is functioning correctly.

7.2. **Demonstration and Instructions**. Demonstrate operation and maintenance of products to the Engineer or their representatives 2 weeks before Substantial Completion.

Use operation and maintenance manuals as basis for instruction. Review contents of the manual with the Engineer or their representatives in detail to explain aspects of operation and maintenance.

Demonstrate start-up, operation, control, adjustment, troubleshooting, servicing, maintenance, and shutdown of each item of equipment at agreed-upon times, at the equipment location.

Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

7.3. **Testing, Adjusting, and Balancing**. The Contractor will appoint, employ, and pay for services of an independent firm to perform testing, adjusting, and balancing.

Reports will be submitted by the independent firm to the Engineer indicating observations and results of tests and indicating compliance or non-compliance with specified requirements and with the requirements of this Item.

8. CONSTRUCTION DEWATERING

Any dewatering required during any phase of construction is the responsibility of the Contractor. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this specification for construction dewatering.

9. MEASUREMENT

The operational building, electrical power and controls, electrical pumps, generators, wet wells, and piping satisfactorily completed in conformance with the plans and specifications to form a fully functional automatic pumping station will be measured by each complete unit.

10. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Automatic Pumping Station–IH 45," at the location specified. This price is full compensation for furnishing and installing a fully operational automatic pumping station and for the equipment required by this Item including buildings, generators, pumps, discharge pipes, sensors, controls, switchgear, electrical systems, wet well, furnishing temporary pumps maintaining existing pumping rate during construction, and for other materials, labor, tools, equipment, and accessories, and incidentals. Any costs associated with providing temporary power and electrical equipment including, but not limited to, generators, panelboards, wiring, and starters to keep existing station in operation during

construction, dewatering, electrical service, and testing are subsidiary to this Item. The work performed, materials furnished, equipment, labor, tools, and incidentals for construction of the wet well will not be paid for directly but are subsidiary to this Item.

Any dewatering required during any phase of construction is the responsibility of the Contractor and is subsidiary to this Item. Provide and install temporary pump for dewatering. Do not use permanent or existing pumps as called for in this Specification for construction dewatering.

Special Specification 7364
Automatic Pumping Station

1. DESCRIPTION

Furnish labor, materials, and equipment necessary to construct a stormwater pumping station at SH 6 near the BNSF Railroad as shown on the plans that is complete, functional, and fully automatic consisting of, but not limited to, the following components.

2. APPROVALS

Upon approval of the above Items, construct the pumping station or any portion of it pertaining to the approved Items.

If an approved Item requires dimensional changes or alterations of the project plans, prepare at no expense to the Department, the necessary plans and submit electronically for approval. Upon approval, proceed with that portion of the pumping station affected by the change.

No changes are permitted in the list of equipment or shop drawings once approved, unless authorized in writing. Approved equipment and plans constitute final plans for construction of the pumping station. Approval, in no way relieves the Contractor or equipment suppliers of any responsibilities described elsewhere in these Specifications.

3. OPERATIONS AND MAINTENANCE MANUALS

Upon determination of the equipment to be used in this station and before final acceptance of this project, furnish the Engineer three binders each containing the following:

Submit documents with 8-1/2 in. × 11 in. pages, bound in 3-ring or D binders with durable plastic covers. Subdivide contents with permanent page dividers, logically organized to the Table of Contents, with tab titling clearly printed under reinforced laminated plastic tabs. Prepare a Table of Contents for each volume, with each product or system description identified.

Part 1: Directory: Listing of names, addresses, and telephone numbers of Design Consultant, Contractor, Subcontractors, and major equipment suppliers.

Part 2: Operation and maintenance instructions, arranged by system. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers and include the following.

- Significant design criteria,
- List of Equipment,
- Parts list for each component,
- Operating instructions,
- Maintenance instructions for equipment and systems, and
- Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

Part 3: Project documents and certificates, including the following.

- Shop drawings and product data,
- Air and water balance reports,
- Certificates, and
- Photocopies of warranties.

Equipment Operation and Maintenance (O&M) Data-Furnish O&M Manuals, prepared by the manufacturer. Manuals must contain, as a minimum, the following items.

- Equipment functions, normal operating characteristics and limiting conditions;
- Assembly, installation, alignment, adjustment, and checking instructions;
- Operating instructions for start-up, normal operation, regulation and control, normal shutdown and emergency shutdown;
- Lubrication and detailed maintenance instructions. Maintenance instructions are to include detailed plans giving location of each maintainable part and lubrication point and detailed instructions on disassembly and reassembly of equipment.

- Troubleshooting guide;
- Complete spare parts list with predicted life of parts subject to wear, lists of spare parts recommended on hand for both initial start-up and for normal operating inventory, and local or nearest source of spare parts availability.
- Outline, cross-section, and assembly plans; engineering data; wiring diagram;
- Test data and performance curves;
- The complete sequence and full description of operating instructions, noting any precautions; and
- Bound copies of warranties and guarantees with dates of expiration, also names and addresses of persons providing warranties and guarantees.

4. COMPONENTS

4.1. **Basic Mechanical Materials and Methods**. Mechanical Systems must be complete, including miscellaneous materials, and ready for operation in conformance with the plans and Specifications.

4.1.1. **Quality Assurance**.

- **Materials and Equipment**: Use standard products of manufacturers regularly engaged in production of such materials and equipment, unless otherwise indicated.
- **Design**: Use manufacturer's latest standard design conforming to this Item.
- When two or more units of same class of equipment are required, supply products from the same manufacturer.
- Where materials and equipment are specified to meet requirements of standards or organizations such as Underwriters Laboratories (UL), American Society for Mechanical Engineers (ASME), etc. that use a label or listing as a method of indicating compliance, such label or listing must be attached to the material or equipment when delivered to the jobsite.
- Each major component of equipment must have the manufacturer's name, address, and model number on a metal nameplate attached to the item of equipment.
- **Qualifications**:
  - Welders must be AWS-certified.
  - Structural and Miscellaneous Fabricated Steel Used in Equipment must conform to AISC standards, except where otherwise specified.
- Design structural members for appropriate shock and vibratory loads.
  - Steel partially or totally submerged during operation of equipment must be at least 1/4 in. thick, unless otherwise specified.
  - Materials and workmanship must conform to standards of SMACNA.

4.1.2. **Submittals**. The following items are required as part of the submittals.

4.1.2.1. **Product Data**. Submit data for materials other than manufacturers' standard products.

4.1.2.2. **Shop Drawings**. Include descriptive and published details concerning performance, capacity, and noise ratings for each piece of equipment.

- For electrical motor-driven equipment, include schematic drawings showing coordination with electrical system including rated horsepower and full load current requirements.
- For electric motors 3/4 Horsepower and larger, furnish the following information.
  - Locked rotor current,
  - Power factor at full and 3/4 load,
  - Efficiency at full load and rated operation condition,
  - Type of bearings,
  - Lubrication requirements,

- Net weight, and
- Catalog data for materials other than equipment that are manufacturer's standard products.

■ Provide scaled mechanical layout drawings showing:
- Dimensioned plan views and elevations of mechanical equipment,
- Equipment mounting and foundations, including anchoring details,
- Piping and duct work, including support detail, and
- Components, including space requirements, coordination with building features, and other work.

4.1.2.3. **Quality Assurance and Control Submittals**. Provide manufacturer's instructions and recommendations for installation, handling and storage, and cleaning and maintenance of equipment and materials during storage and before initial energizing.

4.1.2.4. **Certificates**.

■ **General**: Provide manufacturer's certificates for material and equipment listed.
- Pipe, fittings, and valves 8-in. and smaller in diameter.
- Pipe, fittings, and valves larger than 8-in. diameter: Follow individual Specification sections for submittal requirements.

■ **Welding**: Provide evidence that each welder is certified for type of welding required following American Welding Society (AWS).

4.1.3. **Delivery Storage and Handling**.

4.1.3.1. **Packing, Shipping, Handling, and Unloading**.

Materials and Equipment: Box, crate, or otherwise completely enclose and protect during shipment, handling, and storage, and clearly label with manufacturer's name, brand, or model designation, type or grade, and color.

Packing Lists and Bills: Include complete packing lists and bills with each shipment.

Tagging and Marking: Each item of equipment tagged or marked with same identification number or mark shown on packing lists and bills of material.

4.1.3.2. **Storage and Protection**.

General: Protect materials and equipment from exposure to elements and keep dry. Handle and store to prevent damage, following manufacturers' recommendations.

- Protect insulation, controls, and electrical equipment from moisture and water damage.

■ Store pumps, motors, electrical, and other equipment with antifriction or sleeve bearings in weather tight areas maintained above 60°F.

Space Heaters Furnished in Equipment: Connected during storage and operated continuously.

Protect equipment and material from rust, pitting, decay, or other deleterious effects from storage and handling. Repair or replace material and equipment showing such effects or damage, as directed.

4.1.4. **Project Conditions**.

■ General: Plans indicate extent and general arrangement of equipment, piping, and ductwork.
- Fit equipment into space allotted and allow adequate clearance for entry, installation, replacement, servicing, and maintenance.
- Verify actual and final arrangement, location, grades, and elevations of equipment, appurtenances, piping, and ducts before ordering material and equipment.

- If adjustments and modifications are necessary, submit to Engineer details of such adjustments and modifications and reasons for approval as soon as practicable, but at latest with submittal of scaled mechanical layout drawings.
- Make no adjustments or modifications without Engineer's written approval.
- Coordinate work so equipment may be moved into place without altering building components, other equipment, or installations. Provide drops, rises, or offsets required for proper installation, whether or not shown on the plans.

4.1.5. **Safety Requirements**.

- Enclose or provide guards for belts, pulleys, chains, gears, and other rotating parts to protect operating personnel.
- Guard or cover high-temperature equipment and piping with insulation to protect personnel and prevent fire hazards.
- Provide items such as catwalks, ladders, and guardrails, where required, for safe operation and maintenance of equipment.
- Provide safe working space around equipment.

4.1.6. **Sequencing and Scheduling**. Coordinate sequencing and scheduling of mechanical work with building construction and other related parts of work, including verification that structures, piping, wiring, conduits, and equipment components are compatible.

4.1.7. **Maintenance Materials**. Spare Parts and Extra Materials are specified in the specific Specification Section for equipment or materials.

- Pack into wooden boxes parts listed to be furnished, and label with:
  - Manufacturer’s name, address, and telephone number.
  - Local representative's name, address, and telephone number.
- Names of equipment parts are for and list of parts contained therein.
- Pack extra material in strong cartons, labeled with manufacturer's name, material name, type, color, and location material were installed. Store maintenance material in a location directed.

4.1.8. **Manufacturer Services**.

- Manufacturer’s field representatives of furnished equipment should be onsite during installation, start up, tests, and to instruct the Department personnel on operation and maintenance of equipment.
- Factory trained service and operating personnel should be available to observe, instruct, guide, and direct Contractor's handling, installation, start up, and adjustment procedures of equipment.
- Manufacturer's Services:
- Inspect equipment installed following manufacturer's instructions before but energizing or operating it and supervise equipment start up.
  - Before and during required tests, operate and adjust equipment following plans and specifications.
  - When required in Specification sections for equipment, instruct Department personnel in operation and maintenance of equipment at times and locations approved.

4.1.9. **Products**.

4.1.9.1. **General**.

- In design and supply of equipment, ensure interchangeability of parts and items for equipment, piping, ductwork, motors, and other appurtenances.
- Factory assemble, coat, and paint mechanical equipment as much as practicable before shipping and handling with factory-applied prime coat.

- Nameplate: Attach to each major component of equipment a metal nameplate showing manufacturer's name, address, and equipment model number.

4.1.9.2. **Equipment Bases**.

- Concrete Bases: Unless otherwise indicated, concrete bases must be at least 4-in. thick, and not less than 4-in. larger in both directions than supported unit.
- Cast Iron or Welded Steel Baseplates: Support each unit and its drive assembly on a single baseplate.

4.1.9.3. **Anchor Bolts**.

- Provide anchor bolts, nuts, and washers that are Stainless steel, Type 304.
- Unless otherwise indicated, size anchor bolts to largest diameter that will pass through bolt holes of equipment base.
- Length of Bolts: To permit minimum 1-in. of grout beneath base plate and minimum of 6-in. anchorage into structural concrete.
- Template or Setting Drawing for Anchor Bolts, Nuts, and Washers: Furnish sufficiently in advance to permit anchor bolts to be set either before or during structural concrete placement.

4.1.9.4. **Supports and Braces**. Provide supports and braces fabricated to meet manufacturer’s requirements and as indicated on the plans.

4.1.9.5. **Drive Units**. Provide units that meet the following specifications.

- Nominal Input Horsepower Rating of Gears or Speed Reducers: At least equal to nameplate horsepower of drive motor.
- Drive Units: Designed for 24-hour continuous service.
- Motor and Drive Gears: Rated AGMA Class II and bearing AGMA nameplate.
- Gear Reducers: Totally enclosed, oil lubricated, with antifriction bearings throughout.
  - Worm Gear Reducers: Service factor of at least 1.20.
  - Shaft-mounted Gear Reducers: Rated AGMA Class II.
  - Other Helical, Spiral Bevel, and Combination Bevel-helical Gear Reducers: Service factor of at least 1.50.
  - Gear Reducer Nameplate: AGMA.
- V belt Drive: Service factor of at least 1.60 at maximum speed, with sliding base or other suitable tension adjustment mechanism.
- Variable Speed Drives: Service factor of at least 1.75 at maximum speed, unless specified otherwise.

4.1.9.6. **Coupling, Bearings, Journals, and Keys**. Provide items that meet the following specifications.

- Couplings: Where specified or required between motor and its driven equipment, use flexible standard self-aligning forged steel coupling.
  - Fix and key one hub of coupling to driven equipment shaft with other hub fixed and keyed to abutting drive shaft.
  - Place moisture and dust-proof metal coupling as close as possible to driven equipment and motor bearings so units are arranged in compact manner.
- Bearings: Ball or roller type, with both inner and outer races and balls or rollers made from heat-treated steel, and pressure-grease lubricated, except those specifically requiring lubrication.
- Rollers: Proper size to carry maximum loads without flaking, spalling, or crushing.
  - Balls: Evenly spaced and held in position by continuous spacing or retainer glands.
- Journals and Bearings: Sized and of proportions to create least wear and overheating under most conditions.

- Easy Removal and Adjustment: Where required, make provisions for easy removal and adjustments.
- Journal Lining: When required, line with babbitt metal hammered into grooves and bored in place.
- Keys, Nuts, and Other Parts: Secure parts, which may work loose with locking devices.

4.1.9.7. **Flanges, Jacking Screws, and Eye Bolts**.

- Flange Bolt holes: Drilled with flanges spot-faced on back and stud holes not drilled through.
- Jacking Screws: For covers, where required.
- Eye Bolts for Lifting Covers and Equipment: When manual lifting would be difficult, or where required.

4.1.9.8. **Bolts, Nuts, and Washers**.

- Provide cold pressed nuts.
- For bolts, nuts, and threads, provide American Standard sizes except those used for flanged pipe, valves, fittings, and equipment connections or otherwise noted.

4.1.9.9. **Safety Guards**.

- Cover belt and chain drives, fan blades, couplings, shafts, and other moving and rotating parts on every side by safety guard following OSHA requirements.
- Fabrication: Galvanized or aluminum clad sheet steel or 1/2-in. mesh galvanized expanded metal, 16-gauge or heavier.
- Design for easy installation and removal, with necessary supports and accessories including bolts.
- Outdoor Guards:
  - Design safety guards in outdoor locations to prevent entrance of rain and dripping water.
  - Safety guards: Follow OSHA requirements.
- Supports and Accessories, including bolts: Galvanized or painted following these Specifications and as required.

4.1.9.10. **Access Doors and Panels on Mechanical Equipment**. Provide access doors and panels for easy access to mechanical components that require periodic maintenance and lubrication.

4.1.9.11. **Lubrication**.

- Equipment Lubrication System: Design for weekly adjustment during continuous operation.
  - Lubrication Facilities, Oil Drains, and Fill Openings: Accessible from normal operating area or platform.
  - Drain Ports: Allow for collection of waste oil in containers from operating area or platform without removing unit from its installed position.
- Pressure Grease Fittings: Zerk Hydraulic or Alemite type.
  - Location: Accessible for lubricating with grease gun.

4.1.9.12. **Shop Painting**. Prepare surfaces and shop coat equipment, supports, piping, duct work and appurtenances as specified within the Contract Specification and as shown on the plans, except connecting ends and where it would hinder installation, using shop primer compatible with field coat. Field paint these points after installation.

4.1.9.13. **Special Tools and Accessories**. Where required for adjusting, maintaining, or repairing equipment, including special devices for lifting and handling, such special tools and accessories must be provided complete with the equipment.

4.1.9.14. **Electrical Service**. Mechanical equipment requiring electrical power to operate must be rated for electrical service as shown on the plans and must have enough length of cable and other appurtenances necessary to provide an operational and full functional unit.

If the electrical service is not shown on the plans, the Contractor is still responsible for providing such services as required by the equipment manufacturer at no additional cost to the Department.

4.1.9.15. **Examination and Preparation**.

- Inspect area and surfaces to receive mechanical equipment piping, duct work, and appurtenances, and verify readiness for installation.
- Before installation, repair defects and damaged area, and adjust surfaces and areas for proper installation.
- Field measure and verify adequacy of areas to be occupied by mechanical equipment and appurtenances following approved plans.
- If adjustment is required, obtain Engineer's approval and adjust as approved.

4.1.9.16. **Installation**. Install equipment and appurtenances following Manufacturer's instructions. Provide complete final connections to equipment, including pipe, duct, electricity, and controls.

Isolation Valves and Accessory Fittings: Whether shown or not, install on each side of equipment to allow it to be removed and isolated for servicing. Install manual vents at high points in piping and fitted for hose adapters at low points in fluid piping. Install rises and drops as required by field conditions.

4.1.9.17. **Foundations, Bases, and Supports**.

- General: Support equipment, ductwork, electrical conduits, and piping by providing compatible frames, braces, hangers, and anchors.
- Floor-Mounted Equipment: Unless otherwise shown on the plans, place floor mounted equipment on reinforced concrete pads minimum of 4-in. high.
- Horizontal and Vertical Pumps Mounted on Baseplates or Pedestals: Install following Hydraulic Institute Standards and pump manufacturer's recommendations.
  - Leveling of Baseplate or Pedestal: Use shims or wedges and anchor raised vibratory absorption concrete pad with anchor bolts set in pipe sleeves.
  - Grouting: Fill space between baseplate or pedestal and concrete pad, and void between anchor bolt and pipe sleeve with quick setting and non-shrink grout.
  - Tighten Bolts: After grout has hardened, tighten anchor bolts to equipment manufacturer's recommendations and cut off bolts not more than 1-in. nor less than ½-in. above anchor bolt nut.
- Install Vibration Isolators between equipment base and raised concrete pads on other vibrating or rotating mechanical floor-mounted equipment like fans.
- Anchor Heavy-duty Centrifugal Air Compressors and Blowers following equipment Manufacturer's recommendations.
- Non-vibratory Equipment Suspended Inside Buildings should be braced and supported for rigid installation.
  - Attach supports and hangers to bearing walls, roof, and floor supports, or framing members.
  - Install cross bracing as required to develop rigid installation.
- Suspended Vibratory Equipment should be braced, supported, and provided with cushioning and anti-vibratory material as shown on plans and as recommended by equipment Manufacturer.

4.1.9.18. **Access Panels and Doors for Concealed Equipment**. Provide Access Panels or Hinged Doors where necessary for maintenance and servicing of concealed equipment, piping, ductwork, and fans.

4.1.9.19. **Lubrication**. Lubricate following manufacturer's instructions for initial operation; relubricate following testing and before final acceptance, if directed.

4.1.9.20. **Adjustment and Initial Operation of Equipment**. Before systems and equipment are initially started, clean piping, ductwork, and equipment.

- Check moving parts for freedom of movement, alignment, and adjustment.
- Remove air handling units' temporary filters, check permanent filters, and replace if dirty or damaged.

Manufacturer's Equipment Service: Make adjustments required and recommended by Manufacturer's representative and as required herein, before equipment is energized and operated.

4.1.9.21. **Surface Touch and Field Painting**. Clean field-installed bolts, nuts, washers, and support systems and paint or coat using materials identical to original shop coat and surrounding area. Touch up other surfaces where shop coats have been damaged, using paint, coatings, and film thickness identical to original shop coats. Apply Field Paint as specified and as shown on the plans.

4.1.9.22. **Cleaning and Protection**. Clean equipment, surrounding area, and ductwork inside and out. Protect equipment during and after installation from construction dust and debris. Provide temporary protection as required until equipment is in operation or until receipt of Certificate of Substantial Completion.

4.1.9.23. **Field Quality Control**. Demonstrate and test operation of systems and equipment for specified requirements, in Engineer's presence, following requirements of this Item. Adjust and replace defective equipment and parts as required.

4.1.9.24. **Operation Instructions**. After systems have met field quality control requirements and before issuance of Certificate of Substantial Completion, furnish manufacturer's services for operation and maintenance, as specified for equipment in specific sections.

4.2. **Storm Water Pumps.** Provide labor, materials, equipment, and services necessary to install, test, and place in operation two submersible mixed-flow type pumps with explosion proof motors, with column pipes, and cable suspension system shown on the plans and specified herein. Orient the units and other physical characteristics as shown on the plans. Pump motors must be explosion proof and be capable of running on variable-frequency drives (VFD) and soft-starts.

The physical size and weight of the pumps furnished must be capable of being installed in the wet well, as shown on the plans with no adverse hydraulic effects. The Contractor's attention is directed to the fact that there are limitations as to the size and weight of pump that will be able to be installed. No additional compensation will be paid for installation of the pumps. Contractor is responsible for any damage that may occur to a pump during installation and is responsible for repair or replacement to the satisfaction of the Engineer at no additional cost to the Department.

During construction activities, furnish temporary pumps to maintain the existing pumping rate. Provide necessary design and equipment for the temporary pump.

4.2.1. **Shop Drawings**. Only complete submittal packages including mechanical, electrical, structural, controls and instrumentation equipment will be reviewed. Partial submittal packages will be returned to the Contractor without review.

Submit the following required information for pumps, motors and supports.

- General:
  - Dimensions

- Details of construction and installation

- Motor data:
  - Manufacturer
  - Model
  - Rated horsepower
  - Efficiency
  - Service factor
  - Current and load data
  - Bearing type
  - Bearing calculations
  - Weight
- Pump data:
  - Manufacturer
  - Model
  - Certified performance curves with operating points plotted on curves
  - NPSH curves
- Rated capacities
  - Furnished specialties and accessories
  - Materials of construction
  - Pump orientation
  - Bearing types and lubrication equipment information
  - Seal types
  - Weight
- Pump Start-up and Testing Plan
- Vibration Testing Qualifications
- Operation and Maintenance Manuals:

Submit the following for the pumping equipment.

- Equipment function, normal operating characteristics and limiting conditions.
- Assembly, installation, alignment, adjustment and checking instructions.
- Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions.
- Lubrication and maintenance instructions.
- Guide to “troubleshooting.”
- Parts lists and predicted life of parts subject to wear.
- Outline, cross-sections, assembly drawings, engineering data and wiring diagrams.
- Test data and performance curves.

4.2.2. **References**.

- ASTM A48 – Standard Specification for Gray Iron Castings
- ASTM A743 – Standard Specification for Iron-Chromium Nickel, Corrosion Resistant
- ANSI B16.1 – Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125lb.
- HI 14.6 – Hydrodynamic Pumps for Hydraulic Performance Acceptance Tests
- HI 11.6 – Submersible Pump Tests

4.2.3. **Quality Assurance**.

Design and construct the pumps in conformance with standards of the Hydraulic Institute (HI). The efficiency of the pumps, when operating under conditions of the specified capacities and heads, must be as near peak efficiency as practicable.

Obtain pumping equipment, motors, and appurtenances from a single pump supplier whose responsibility it is to ensure that the pumping equipment is properly coordinated and operated in accordance with these Specifications.

Design and construct mechanical and electrical equipment in conformance with the latest editions of ANSI, HI, and NEMA Standards.

Submit shop drawings certified for construction by the pump manufacturer which includes location of electrical connections; wiring diagrams; anchor bolt layout; details indicating construction and materials of construction; diameter of shafting; gear and bearing ratings; installation drawings showing each pump, suction and discharge piping and fittings, specials, supports, concrete pads, clearances, and dimensions to install the pump in the spaces indicated on the plans.

Qualifications: The manufacturer must have 20 or more years of experience and furnished similar equipment for at least 5 pumping stations.

4.2.4. **Vibration Limits**. The amplitude of vibration of any centrifugal pumping unit, when operating at any of the speeds specified herein must not exceed the requirements set forth in the latest revision of the Hydraulics Institute Standards. The amplitude of vibration for other pumping units must not exceed the requirements of the pump manufacturer's standard.

4.2.5. **Name Plates**. Each pump must be provided with a stainless-steel nameplate, riveted or bolted to the unit with stainless steel hardware. Nameplates must contain the manufacturer's name, equipment size (i.e., HP, impeller diameter, speed, flow, and head, etc.) and type, serial number, and other pertinent data specified herein.

4.2.6. **Delivery, Storage and Handling**.

Preparation for Shipment: Pieces should be delivered in the largest sizes practical for ease of installation within the existing building and ease of minimal field assembly by the Contractor. Individual pieces must be permanently tagged with welded erection marks or stainless-steel tags cross-referenced with information on the manufacturer's erection and assembly drawings. Design field connections ed for static, live, and erection loads.

Protect drive units, mechanical, and electrical components from the weather and suitably packaged to facilitate handling and storage. Provide special lubricating and rust preventative oils to prevent internal corrosion of gear assemblies. Always keep mechanical equipment thoroughly dry and store indoors. Protect and maintain equipment stored on the job in conformance with the manufacturer's recommendations. When requested, provide written certification from manufacturer that the equipment is being properly stored.

Store pumps onsite under cover in conformance with this Item.

4.2.7. **Rejected Material and Replacements**. Reject damaged, deteriorated, or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost.

4.2.8. **Field Services and Warranty**. Provide services of a manufacturer's representative for not less than 2 days on site for installation inspection and field testing for each pump.

The Engineer may elect to rearrange the configuration of the days of site support at his sole discretion. Site visits not used by the manufacturer during the construction period must be made available to the Engineer during the warranty and operations period, not to exceed 2 yr. from the date of conditional acceptance.

Each site visit must be confirmed in writing by a daily log signed by the Engineer and the Manufacturer's representative. Failure of the Manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit and will not be attributed to the completion of the total specified number of site visits.

Manufacturer's Warranty: Period of 5 yr., with no hour limitation, non-prorated, from the date of final acceptance. The warranty must cover pumps and motors against defects in materials and workmanship, including parts and factory or authorized service facility labor.

4.2.8.1. **Spare Parts**. Contractor must provide the following spare parts per pump.

- Impeller
- Wear Rings, 1 of each type
- Mechanical Seal
- One thermal sensor (RTD) per installed location

4.2.9. **Products – Stormwater Pumps**.

- Design pump units for installation into a discharge column onto a seat at the bottom of the column and must be held in place by its own weight and the pumping head. It must be possible to lower the pump in the column and put into operation even when column is filled with water. There should be no need for personal to enter the wet well when removing or reinstalling the pump. The pump must not require any bolts, nuts, or fasteners for connection to the discharge column. An O-ring must be provided on the bottom of the inlet (suction) bell mouth so that the weight of the pump unit, when acting on the O-ring, will provide an effective seal between pump and discharge column.
- Provide a motor and pump manufactured by the same manufacturer.
- Coordinate the maximum outer diameter of the pump housing with the installed application. Where the pump is installed in an existing wet well, the pump column must not exceed the existing opening size. A locking device, located on the external surface of the pump housing, must prohibit rotational movement of the pump or motor unit within the tube.
- Each pump must be equipped with submersible electric motor, capable to operate on a 460 volt, 3 phases, 60 hertz voltage supply. Motor must be inverter duty rated for use with VFD and reduced voltage soft starters.
- The pump must be capable to transport river water and 2 in. screened storm sewer.
- Impeller must be of cast iron, dynamically balanced, multiple-vane, double shrouded non clogging design. It must be equipped with a stainless-steel wear ring.
- The suction inlet of the pump housing must be equipped with a wear ring made of bronze.
- The outlet must have guide vanes designed in such a way as to minimize clogging by carrying debris normally prone to clog the guide vanes from the inside of the guide vanes towards the outside of the guide vane. Here the flow must be partially and deliberately destabilized to help material disengage itself from the vanes, to continue its passage through and out of the pump.
- Performance Requirements:

Flow	6,000 gpm
Head	19.3 ft
Motor Horsepower (maximum)	45 hp
Motor Speed (maximum)	590 rpm
Pump Efficiency	80.9%

- The NPSHR must be below 8 feet.
- The impeller must be mounted on the motor shaft. Couplings or gear boxes will not be accepted.

- The motor must be induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. It must be permanently submersible according to standard IEC 60034 and protection class IP 68.
- The motor must be cooled by the pumped water flowing along the stator housing when the pump is working. A water jacket or any external cooling system must not be considered acceptable designs.
- The motor must be no overloading along the entire pump performance curve and capable of at least 15 evenly spaced starts per hour and be able to operate throughout the entire pump performance curve from shut-off through run-out. To limit mechanical stress to the motor and the power transmission equipment the start current must be enough to start the driven load at a maximum 3.5 x FLC.
- The stator must be insulated according to moisture resistant Class H rated for 356°F. The stator windings must be insulated with monomer-free polyester resin resulting in a winding fill rate of at least 96%. The design must be inverter duty rated in accordance with NEMA MG1, Part 31.
- The junction chamber containing the terminal board must be hermetically sealed from the motor by an elastomeric compression seal. Connection between the cable conductors and stator leads must be made with threaded compression type binding posts permanently affixed to a terminal board.
- Motor Protection: The motor must motor must be protected by following sensors:
  - 3 bi-metal Thermal switches for thermal control of the stator
- 1 PT 100 thermal sensor (RTD) to monitor the stator temperature of 1 Winding.
- 1 PT 100 thermal sensor (RTD) to monitor the temperature of the main bearing.
- 1 Vibration sensor to monitor vibration on 3 axes from 10 – 600 Hz.
- 1 float switch in leakage chamber to monitor leakage in the leakage chamber.
- 1 float switch in the terminal connection housing to monitor any leakage thru the cables and the cable entries.
- The pump must be supplied with a Pump Electronic Module (PEM) mounted inside the motor. The PEM must collect, store, and digitize measurement from the sensors and must communicate the data in a digital format via 2 control leads integral to the pump power cable to a Base unit mounted in a pump control cabinet to the Central control unit. The pump must have no more than one cable entry including power and communication.
- The pump electronic module (PEM) must also supply information about the pump as well as features for start-up and service support, such as:
  - Pump serial number and other data plate information.
  - Specific configuration of monitoring functions for the actual pump such as alarm limits, delays, reset types, etc.
- Counters by which the system can generate service reminders in conformance with the service policy specified in the pump manual.
  - Operating data and alarm history to analyze the condition of the pump and enable troubleshooting and reporting.
  - Accumulated running time and number of starts.
  - Pump duty rate (percentage of operation).
- The cable entry must consist of dual cylindrical elastomer sleeves, flanked by washers and with a close tolerance fit against the cable and the cable entry. Epoxies, silicones, or other secondary sealing systems will not be considered acceptable.
- The pump shaft must rotate on at least three grease-lubricated bearings. The upper bearing, provided for radial forces, must be a single roller bearing. The lower bearings must consist of at least one roller bearing for radial forces and one or two angular contact ball bearings for axial thrust. The minimum L10 bearing life must be 100,000 hours at any point along the usable portion of the pump curve at maximum product speed. The lower bearing housing must include a thermal sensor (RTD) of the platinum-100 type to monitor the temperature of the thrust bearing outer race during operation temperature. If a high temperature occurs, the sensor must activate an alarm. The upper support bearing must have an

insulated outer ring to provide protection against electrically induced currents that can be created when the motor is used with a VFD.

- The shaft seal must be a positively driven dual, tandem mechanical shaft seal system consisting of 2 seals, each with an independent spring system. The seal is in a separate lubricant chamber and is lubricated and cooled by environmentally friendly medical white oil. The lubricant chamber must be designed to prevent over-filling and must provide capacity for lubricant expansion. It must have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seal system must not rely upon the pumped media for lubrication. The seals must require neither maintenance nor adjustment and must be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal function. The rotating inner seal ring must have small back-swept grooves laser inscribed upon its face to act as a micro pump as it rotates, returning any fluid that should enter the dry motor chamber back into the lubricant chamber. Shaft seals without positively driven tandem mechanical seal or conventional double mechanical seals that are either carried out with a common single or double spring are not accepted. Any leakage passing the sealing must not pass the bearings. Before it reaches the bearings, the liquid must create an alarm via the floating leakage sensor.
- The Materials of construction must meet the following Specifications:
  - Pump housing & Inlet Cone: ASTM A-48, Class 35B
  - Impeller: Cast iron ASTM A-48, Class 35B
  - Rotating wear ring: Stainless steel
  - Stationary wear ring: Bronze ASTM B271+B505/C 83600
  - Stator housing: ASTM A-48, Class 35B
  - Shaft: ASTM A479 S43100-T.
  - Shaft seal: Pump side: - Corrosion resistant Tungsten carbide (WCCR)
  - Shaft seal Motor side: - Corrosion resistant Tungsten carbide (WCCR)
- Blast castings before coating. Coat wet surfaces with two-pack oxirane-ester Duasolid 50. The total layer thickness must be at least 120 microns. Zink dust primer must not be used.
- The motor must be equipped with screened cable suitable for submersible pump applications. Coordinate cable length with field installation requirements. Size the power cable according to NEC and ICEA standards. The outer jacket of the cable must consist of oil resistant chlorinated polyethylene rubber. The cable must be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet. Supply a cable support grip with the cable.
- Pump Retrieval System: Incorporate the Pump Retrieval System into the pump design. Furnish a pump capable of being removed by a single Type 304 stainless steel wire rope and lifted easily, securely, and safely in one continuous motion. Provide properly sized stainless steel thimble eyes and shackles. Provide a wire rope assembly with a minimum safety factor of 3:1 based on the breaking strength of the wire rope and the weight of the pump. Submit the lifting technique for approval. Use stainless steel hardware.
- Pump Column and Discharge Pipe. Use steel pipe per ASTM A 53 Type E, Grade A or B, API-5L, or ASTM A36 rolled and seam welded plate, sized as shown on plans.
- Weld Flanges. Supply 125 lb., flat face, slip-on registered machined steel in conformance with AWWA C207, Class B. Use full face flange gaskets made of neoprene rubber.
- Provide protective pipe coatings suitable for immersion service. Prepare surfaces per the manufacturer's requirements. Provide one coat Series V69 Hi-build Epoxoline II at 3-4 mils dry film thickness (DFT) and two coats Series 435 Perma-glaze at 7-9 DFT per coat as manufactured by Tnemec or equivalent system. Apply one Coat: Phenoline 311 at 2-3 mils DFT and one coat Plastie 4500S at 45-55mils DFT as provided by Carboline or approved equal. Provide color chart for Department selection.
- Gaskets. Provide 125 lb., full face, neoprene rubber gaskets.
- Bolts. Use ASTM A 193-B7 hex head bolts with ASTM A194-2H nuts, hot dip galvanized.

- Adapter Flange. Use mechanical joint type adapter flanges, manufactured from ductile iron, ASTM A536 Grade 65-45-12, Class 125, Series 400 Uni-Flange with set screws and SBR (Buna-S) gasket. Use a galvanized flange.
- T-bolt Hinged Closure. Proved a closure made of carbon steel with a semi-ellipsoidal head hinged to a matching hub prepared for welding to the pipe column, with a self-energizing Buna-N O-ring and a suitable number of T-bolts to effect and maintain a tight seal and is rated at 90 psi min. at 250°F. Ensure it is quickly and easily opened with the cover swung back on its hinges to allow complete and unrestricted access. Supply T-bolts with attached break-over wrenches. Provide a hot dip galvanized closure with proper size pipe couplings for pump cables welded in place.
- Supply pumps from the one of the following manufacturers: Flygt Model LL3356, KSB, or approved equal. Pump basis of design is Flygt. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the Contractor with no extra cost to the owner.

4.2.10. **Execution**.

4.2.10.1. **Installation**. Install the pumping systems in complete compliance with applicable requirements of the latest edition of ANSI/HI and the manufacturer's recommendations. Remove the existing sump pumps from operation before initiation of activities within an area. Install and maintain temporary sump pumps for the duration of construction activities within an area.

4.2.10.2. **Start-up Services and Training**.

The manufacturer must furnish the service of a qualified, factory-trained service representative who must inspect the complete equipment installation under the supervision of the Pump Control System Supplier to ensure that it is installed in conformance with the manufacturer's recommendations, make any adjustments necessary to place the system in trouble-free operation, and instruct the operating personnel in the proper maintenance and operation of the equipment furnished.

The Department reserves the right to videotape and archive start-up and training instruction provided by the manufacturer or authorized representative.

After the pumps have been completely installed and wired, the manufacturer's service representative must perform the following.

- Megger stator and power cables
- Check seal lubrication.
- Check for proper rotation.
- Check power supply voltage.
- Measure motor operating load and no-load current.
- Check level control operation and sequence.
- Make adjustments, as necessary.

Furnish a written start-up report providing measurements and readings, confirming checks and inspections, indicating adjustments made, and certifying that the installation and operation is in compliance with the Specifications and the pump manufacturer's recommendations. The manufacturer's representative must provide tools and test equipment required to perform testing. Should the manufacturer's representative fail to provide the necessary testing equipment, the start-up will be rescheduled at the Contractor's expense. The Contractor will not be entitled to additional time or money due to the need to reschedule testing.

Start-up services pertaining to instrumentation and control must be under the supervision of the Pump Control System Supplier.

4.2.10.3. **Testing**.

4.2.10.3.1. **Factory Testing**. Perform testing of each pump on a Hydraulic Institute (HI) compliant test stand in a facility located in one of the contiguous 48 United States. Test each pump in conformance with the latest HI Standards and must include the following:

- Check impeller, motor rating, and electrical connections for compliance with this Specification.
- Before testing, run each pump to establish correct rotation.
- Each pump must be run in air.
- Test motor and cable insulation for moisture content for insulation defects.

Furnish a writing quality assurance record for each pump, confirming the above inspections and testing, at the time of the shipment.

Each pump supplied must be tested in conformance with the latest HI Standards at the factory to determine the criteria listed below. Performance curves for the listed criteria must be based on at least seven evenly spaced test points, including shutoff (or as near to it as possible), 1/4, 1/2, 3/4, 4/4, and two additional points. Perform testing points and provided in accordance with HI Test Acceptance Grade 1U; no negative tolerances will be allowed for any tested parameter. At a minimum, provide performance curves for pump and motor speeds of 50%, 75%, 100%, and the two speeds required to meet the design flow and minimum flow listed above. Test each supplied pump for the following criteria:

- Pump head and efficiency versus capacity
- Motor power, efficiency, and horsepower draw versus capacity, and
- Pump Net Positive Suction Head Required (NPSHR) vs capacity.

Furnish 8 copies of certified performance curves and test reports for each pump before shipment. Data must be reported in Standard English units.

4.2.10.3.2. **Field Testing**. Perform field tests for the purpose of accepting the pumps for mechanical integrity. Submit a proposed test procedure to the Engineer for approval. Contractor must provide necessary instrumentation.

Perform tests with potable water only. Providing water for the testing.

Tests must first establish that the pump H-Q curves are roughly tracking the factory test curves. At a minimum, 5 evenly spaced test points must be provided. These must include, while the pump is running at full speed: shutoff, full capacity, 1/2 capacity and two additional points as directed. Record motor amps and pressure for each point.

After determining that the pumps are performing per the factory H-Q curves, exercise the pump for not less than one hour per pump. Demonstrate that pump, motor, and vibration does not exceed ANSI/HI limits and bearing temperatures do not exceed the manufacturer’s recommendations. Vibration testing must be performed by a qualified independent testing agency.

Procure the services of an independent vibration testing agency to measure the vibration and the operating speed of the modified pumping unit under actual operating conditions.

Conduct testing in the presence of the Engineer. Testing must be conducted by a firm or individual whose qualifications are subject to the approval of the Engineer. Testing results must be documented by the Contractor and submitted to the Engineer for approval.

If any equipment fails the vibration tests, replace such equipment or make adjustments until vibration falls within the specified limits. Replacement, adjustments, and retesting will be performed entirely at Contractor's expense.

4.3. **Sludge Pump**. Provide labor, materials, equipment, and services necessary to furnish, install, test, and place in operation a submersible solids handling type pump with explosion proof motor as shown on the plans and specified herein. Orient the units and other physical characteristics as shown on the plans.

Provide sludge pumps of the physical size and weight of the pumps capable of being installed in the wet well, as shown on the plans. The Contractor's attention is directed to the fact that there are limitations as to the size and weight of pump that will be able to be installed. No additional compensation will be paid for installation of the pumps. Contractor will be responsible for any damage that may occur to a pump during installation and will be responsible for repair or replacement to the satisfaction of the Engineer at no additional cost to the Department.

4.3.1. **Shop Drawings**. Only complete submittal packages including mechanical, electrical, structural, controls and instrumentation equipment will be reviewed. Partial submittal packages will be returned to the Contractor without review.

Submit the following required information for pumps, motors and supports.

- General:
  - Dimensions
  - Details of construction and installation
- Motor data:
  - Manufacturer
  - Model
  - Rated horsepower
  - Efficiency
  - Service factor
  - Current and load data
  - Bearing type
  - Bearing calculations
  - Weight
- Pump data:
  - Manufacturer.
  - Model.
    - Certified performance curves with operating points plotted on curves.
    - NPSH curves
- Rated capacities
    - Furnished specialties and accessories.
    - Materials of construction.
    - Pump orientation.
    - Bearing types and lubrication equipment information.
    - Seal types.
    - Weight.
- Pump Start-up and Testing Plan
- Vibration Testing Qualifications
- Operation and Maintenance Manuals:

Submit the following required information for the pumping equipment.

- Equipment function, normal operating characteristics and limiting conditions
- Assembly, installation, alignment, adjustment and checking instructions
- Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions

- Lubrication and maintenance instructions
- Guide to “troubleshooting”
- Parts lists and predicted life of parts subject to wear
- Outline, cross-sections, assembly drawings, engineering data and wiring diagrams
- Test data and performance curves

4.3.2. **References**.

- ASTM A48 – Standard Specification for Gray Iron Castings
- ASTM A743 – Standard Specification for Iron-Chromium Nickel, Corrosion Resistant
- ANSI B16.1 – Standard for Cast Iron Pipe Flanges and Flanged Fittings, 125lb.
- HI 14.6 – Hydrodynamic Pumps for Hydraulic Performance Acceptance Tests
- HI 11.6 – Submersible Pump Tests

4.3.3. **Quality Assurance**.

Design and construct the pumps in conformance with standards of the Hydraulic Institute. The efficiency of the pumps, when operating under conditions of the specified capacities and heads, must be as near peak efficiency as practicable.

Obtain pumping equipment, motors, and appurtenances from a single pump supplier whose responsibility it is to ensure that the pumping equipment is properly coordinated and operated in accordance with this Item.

Design and construct mechanical and electrical equipment in conformance with ANSI, HI, and NEMA Standards, latest editions.

Submit shop drawings certified for construction by the pump manufacturer which includes location of electrical connections; wiring diagrams; anchor bolt layout; details indicating construction and materials of construction; diameter of shafting; gear and bearing ratings; installation drawings showing each pump, suction and discharge piping and fittings, specials, supports, concrete pads, clearances, and dimensions to install the pump in the spaces indicated on the plans.

Qualifications: The manufacturer must have 20 or more years of experience and furnished similar equipment for at least 5 pumping stations.

4.3.4. **Vibration Limits**. The amplitude of vibration of any centrifugal pumping unit, when operating at any of the speeds specified herein must not exceed the requirements set forth in the latest revision of the Hydraulics Institute Standards. The amplitude of vibration for other pumping units must not exceed the requirements of the pump manufacturer’s standard.

4.3.5. **Name Plates**. Each pump must be provided with a stainless-steel nameplate, riveted or bolted to the unit with stainless steel hardware. Nameplates must contain the manufacturer’s name, equipment size (i.e., HP, impeller diameter, speed, flow, and head, etc.) and type, serial number, and other pertinent data specified herein.

4.3.6. **Delivery, Storage and Handling**.

Preparation for Shipment: Deliver pieces in the largest sizes practical for ease of installation within the existing building and ease of minimal field assembly by the Contractor. Individual pieces must be permanently tagged with welded erection marks or stainless-steel tags cross-referenced with information on the manufacturer's erection and assembly drawings. Design field connections for static, live, and erection loads.

Protect drive units, mechanical and electrical components from the weather and suitably package to facilitate handling and storage. Provide special lubricating and rust preventative oils to prevent internal corrosion of

gear assemblies. Mechanical equipment must be always kept thoroughly dry and must be stored indoors. Protect equipment stored on the job and maintain in conformance with the manufacturer's recommendations. When requested, provide written certification from manufacturer that the equipment is being properly stored.

Store pumps on site under cover in accordance with this Item.

4.3.7. **Rejected Material and Replacements**: Reject damaged, deteriorated, or contaminated material and immediately remove from the site. Replace rejected materials with new materials at no additional cost.

4.3.8. **Field Services and Warranty**.

Provide services of a manufacturer’s representative for not less than 2 days on site for installation inspection and field testing for each pump.

The Engineer may elect to rearrange the configuration of the days of site support at his sole discretion. Site visits not used by the manufacturer during the construction period must be made available to the Engineer during the warranty and operations period, not to exceed 2 yr. from the date of conditional acceptance.

Confirm in writing each site visit by a daily log signed by the Engineer and the Manufacturer’s representative. Failure of the Manufacturer’s representative to obtain a signature from the Engineer will result in the disqualification of the site visit and will not be attributed to the completion of the total specified number of site visits.

Manufacturer’s Warranty: Period of 5 yr., with no hour limitation, non-prorated, from the date of final acceptance. The warranty must cover pumps and motors against defects in materials and workmanship, including parts and factory or authorized service facility labor.

4.3.9. **Spare Parts**. Provide the following spare parts for each pump: Impeller and 1 of each type of wear ring.

4.3.10. **Products – Sludge Pumps**.

Ensure it is possible to lift and lower the pump on parallel guide bars and connect it to wet well mounted discharge connection. There must be no need for personal to enter the wet well when removing or reinstalling the pumps.

Sealing of the pump unit to the discharge connection must be accomplished by a machined metal to metal watertight contact. Sealing of the pump discharge interface with an O-ring, diaphragm or profile gasket is not acceptable.

The impeller must be a semi open multi vane self-cleaning impeller designed to transport wastewater with fibrous materials like wet wipes. Impeller must be wear resistant against sand and grit which is expected to enter the pump station with the sewage or storm water.

Performance Requirements:

Flow	567 gpm
Head	28.7 ft
Motor Horsepower (maximum)	10 hp
Motor Speed (maximum)	1,961 rpm
Pump Efficiency	53.2%

The NPSHR must be below 12.4 feet.

The manufacturer must guarantee clog-free operation for a period of 24 mo. from the date of start-up of the pumps by the local authorized factory representative. A certificate must be provided to the Department on the day of start up with the local contact information and effective date. Should the impeller clog with typical solids or modern trash debris normally found in domestic wastewater during this period, an authorized representative must, either travel to the jobsite, remove the pump, clear the obstruction, and reinstall the pump at no cost or reimburse the Department for reasonable cost to provide this service. Provide a written report to the Department detailing the service call with pictures for verification purposes.

The pump must be equipped with a submersible synchronous electric motor, capable to operate on a 380-480 volt, 3 phase, 60 hertz voltage supply. The starting current must not exceed 14 A.

Pump must be capable of handling raw domestic wastewater or stormwater with fibrous materials like wipes.

The impeller blades must be self-cleaning upon each rotation as they pass across a sharp relief groove in the Insert ring and must keep the impeller blades clear of debris. The insert ring must have a guide pin which moves fibers from the center of the impeller to the leading edges of the impeller. The impeller must move axially upwards to allow larger debris to pass through and immediately return to normal operating position. The clearance between the insert ring and the impeller leading edges must be adjustable.

Due to the likely presence of sand and or grit, the impeller and the cutting ring must be made of ASTM A532 Alloy III A with 25% chrome. Impellers that have surface hardening or coating will not be allowed.

The pump must be capable to operate without any limitation between 50% and 150% of the best efficiency point (B.E.P) of the performance curve.

The pump the motor and the integrated control system must be submersible at least 65 ft. according to IEC 60034 and protection class IP 68. Motors which only can be submerged for a limited time (IP 67) must not be considered as equal.

The motor must be capable to operate the pump at continuous duty (S1) in an ambient temperature up to 104°F. Operational restrictions or the demand of auxiliary cooling systems like fans or blowers are not acceptable. Motor must be non-overloading along the entire pump performance curve.

The pump must be operated by a synchronous motor and an integrated control system and be capable to run at constant power at any point of the performance field without being overloaded. Motor must use a permanent magnet rotor to maintain synchronous speed.

The motor must be capable of withstanding at least 60 starts per hour. Motor must be explosion proof rated.

The discharge flange of the pump must be 4-in. minimum and drilled according to ANSI B16.1-89; tab.5.

The impeller must be mounted on the motor shaft. Couplings will not be accepted.

Pumps must be equipped with an integrated pump control system installed in the pump/motor housing which must start the pump by gradually increasing the pump speed. The starting current must not be higher than the rated current.

An integrated pump control system installed in the pump motor housing must secure the correct direction of the impeller rotation. There must be no need for any human intervention to ensure that the impeller is rotating in the correct direction within the volute. The integrated control system must be inside the motor and encapsulated to protect it against moisture ingress and vibration.

The motor and the pump control system must receive enough cooling from the pumped liquid to continuously operate the pump in a liquid at a temperature of 104°F. Operational restrictions on the liquid temperature below 104°F or the demand of auxiliary cooling systems like fans or blowers are not acceptable. The Stator

must be inverter duty rated in accordance with NEMA MG1, Part 31 and be insulated according to Class H (356°F).

Motor, pump, and control system must be designed and supplied by the pump manufacturer.

The control system must continuously monitor the leakage sensor in the stator housing and the temperature of the motor. It must be impossible to overload the motor. If the motor temperature is too high, the pump must continue to operate at reduced power until conditions are normalized. External trips or overload devices for motor protection must not be required.

The operator must be able to modify the setting of the control system to decide if the active leakage signal must stop or not stop the pump.

The pump must incorporate a “pump-cleaning” function to remove debris from the impeller. The cleaning function must be initiated when the integral control system senses an increase in current draw due to debris in the pump. The cleaning function must consist of forced stopping, reversal and forward runs timed to allow for debris to fall from the impeller. After the cleaning cycle is complete, the pump must resume to automatic operation. If the pump impeller/volute does not clear itself after the programmed number of attempts, the control must initiate and alarm to notify that the pump inlet/volute is blocked by large debris.

Provide a Human Machine Interface (HMI) making it possible to access and adjust the pump system. The HMI should consist of a unit ranging from basic monochrome displays to full-color touch screen units and smartphone or tablet. It must enable the operator to view and control entire pump system and logged operational data like number of starts, avoided clogging instances, pump run-time, motor power, motor current, power factor, temperature, pump leakage etc.

PCP and Sludge Pump Control Panels HMI/OIT’s. Provide 15 in. Harmony GTU, Magelis GTU, or approved equal. Supply the HMI/OIT with the necessary HMI software, drives, and the other development tools to provide a complete and functional system in accordance with the Contract Documents.

The shaft must rotate on two bearings. The motor bearings must be sealed and permanently grease lubricated with high temperature grease. The upper motor bearing must be a single-row ball bearing to handle radial loads. The lower bearing must be a double-row, angular contact ball bearing to handle the thrust and radial forces. Single row lower bearings are not acceptable. The minimum L10 bearing life must be 50,000 hours at any usable portion of the pump performance field.

The shaft must be sealed by a tandem mechanical shaft seal system consisting of two seals, each with an independent spring system. The seals must require neither maintenance nor adjustment and must be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal function.

Where a seal cavity is present in the seal chamber, the area about the exterior of the lower mechanical seal in the cast iron housing must have cast in an integral concentric spiral groove. This groove must protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

The Materials of construction must be as follows:

- Pump housing: ASTM A-48, Class 35B
- Impeller and insert ring: A 532 ALLOY III A (25% chrome)
- Stator housing: GD-AL SI 12 or ASTM B85A 413
- Shaft: ASTM A479 S43100-T.
- Shaft seal: Pump side: - Corrosion resistant Tungsten carbide (WCCR)
- Shaft seal Motor side: - Corrosion resistant Tungsten carbide (WCCR)

Blast castings before coating. Coat wet surfaces with two-pack oxirane ester Duasolid 50. The total layer thickness must be at least 120 microns. Zinc dust primer must not be used.

The motor must be equipped with screened cable S3x6+3x6/3+S(4x0,5) suitable for submersible pump applications. Cable length must be coordinated with field installation requirements. The power cable must be sized according to NEC and ICEA standards. The outer jacket of the cable must be oil resistant chlorinated polyethylene rubber. The cable must be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet.

Each pump must be supplied with a mating cast iron discharge connection. The pumps must be automatically and firmly connected to the discharge connection, guided by at least two stainless steel guide bars extending from the top of the station to the discharge connection to ensure pump stability when installing or removing the machine. There must be no need for personnel to enter the wet well to access the pump. Sealing of the pumping unit to the discharge connection must be accomplished by a machined metal to metal watertight contact. Sealing off the discharge interface with a diaphragm, O-ring or profile gasket must not be acceptable. No portion of the pump must bear directly on the wet well floor.

The guide rail system must consist of two parallel 2 in. guide bars, supported by pump manufacturer supplied upper guide rail brackets. Guide bars and guide brackets must be Type 304 Stainless Steel.

Each pump must be fitted with stainless steel lifting cable. Lifting cable must be connected to the lifting handle of the pump and be long enough to reach the top elevation of the station. Lifting chain must be compatible with the Grip-Eye Pump Lift System. The working load of the lifting system must be 50% greater than the pump unit weight.

Provide one pump lift system Grip-Eye for each pump. The Grip-Eye must allow for utilizing a hoist for lifting each pump from its installed position to above the top elevation of the station. The Grip-Eye device must be configured to slide down the stainless-steel lifting chain and grip the lifting chain near pump handle. The retrieval system must be appropriately sized for the weight of the pump to be lifted.

Supply submersible cable connection boxes meeting the requirements of NEMA 6P. The submersible cable of the pump must be connected to the wall mounted Power & monitoring cables in a cable connection box to ease the installation and disassembling of the pumps. The cable connection box must be submersible NEMA 6P (IP 67) to secure that no water can enter the motor via the cables even when the complete station is flooded.

Sump Pump Discharge Line. Provide the following components:

- Discharge Pipe and Fittings. Provide flanged ductile iron, Class 54 pipe with Protecto 401 ceramic epoxy lining. Provide Class 125 flanges and coordinate flanges with the connecting equipment. Where flange adapters are necessary, utilize EBAA Iron Megaflange 2100 or equivalent from Star Pipe Products. Provide fittings and pipe from the same manufacturer. Provide 1/8 in. thick, AWWA C207 gaskets. Test piping in accordance with AWWA C600 to 1-1/2 times the working pressure, but not less than 150 psi.
- Provide protective pipe coatings suitable for immersion service. Prepare surfaces per the manufacturer's requirements. Provide one coat Series V69 Hi-build Epoxoline II at 3-4 mils dry film thickness (DFT) and two coats Series 435 Perma-glaze at 7-9 DFT per coat as manufactured by Tnemec or equivalent system. Apply one Coat: Phenoline 311 at 2-3 mils DFT and one coat Plastie 4500S at 45-55mils DFT as provided by Carboline, or approved equal. Provide color chart for Department selection.
- Bolts. Provide stainless steel bolts and nuts for flanged piping, fittings, and couplings.
- Pipe Coupling. Provide restrained coupling as manufactured by Smith Blair, Romac, Dresser, Rockwell or equal. Provide high strength stainless steel nuts and bolts.

- Check Valve. Provide iron body, sinking ball type check valve, flanged, suitable for vertical installation with exterior coating per manufacturer standard coating. Design should be non-clogging and self-cleaning. Valve should be resilient seated and provide full port flow path. Provide ductile iron bonnet, stainless steel bolts, and aluminum core ball vulcanized with rubber on every side. Provide valve from VAG Group, G.A. Industries, or approved equal.

4.3.11. **Execution**.

4.3.11.1. **Installation**. Installation of the pumping systems must be in complete compliance with applicable requirements of the latest edition of ANSI/HI and the manufacturer's recommendations. Remove existing sump pumps from operation before initiation of activities within an area. Install and maintain temporary sump pumps for the duration of construction activities within an area.

4.3.11.2. **Start-up Services and Training**.

Furnish the service of a qualified, factory-trained service representative who must inspect the complete equipment installation under the supervision of the Pump Control System Supplier to ensure that it is installed in conformance with the manufacturer's recommendations, make adjustments necessary to place the system in trouble-free operation, and instruct the operating personnel in the proper maintenance and operation of the equipment furnished.

The Department reserves the right to videotape and archive start-up and training instruction provided by the manufacturer or authorized representative.

After the pumps have been completely installed and wired, the manufacturer's service representative must perform the following:

- Megger stator and power cables
- Check seal lubrication.
- Check for proper rotation.
- Check power supply voltage.
- Measure motor operating load and no-load current.
- Check level control operation and sequence.
- Make adjustments, as necessary.

Furnish a written start-up report providing measurements and readings, confirming checks and inspections, indicating the adjustments made, and certifying that the installation and operation is in compliance with the Specifications and the pump manufacturer's recommendations. The manufacturer's representative must provide the tools and test equipment required to perform testing. Should the manufacturer's representative fail to provide the necessary testing equipment, the start-up will be rescheduled at the Contractor's expense. The Contractor will not be entitled to additional time or money due to the need to reschedule testing.

Start-up services pertaining to instrumentation and control must be under the supervision of the Pump Control System Supplier.

4.3.12. **Testing**.

4.3.12.1. **Factory Testing**. Test each pump on a Hydraulic Institute (HI) compliant test stand in a facility located in one of the contiguous 48 United States. Test each pump in conformance with the latest HI Standards and must include the following:

- Check impeller, motor rating, and electrical connections for compliance with this Specification.
- Before testing, run each pump to establish correct rotation.
- Each pump must be run in air.
- Test motor and cable insulation for moisture content for insulation defects.

Furnish a writing quality assurance record for each pump, confirming the above inspections and testing, at the time of the shipment.

Test each supplied pump in conformance with the latest HI Standards at the factory to determine the criteria listed below. Performance curves for the listed criteria must be based on at least seven evenly spaced test points, including shutoff (or as near to it as possible), 1/4, 1/2, 3/4, 4/4, and two additional points. Perform testing points, provided in accordance with HI Test Acceptance Grade 1U; no negative tolerances must be allowed for any tested parameter. At a minimum, performance curves must be provided for pump and motor speeds of 50%, 75%, 100%, and the two speeds required to meet the design flow and minimum flow listed above. The following criteria must be tested for each supplied pump:

- Pump head and efficiency versus capacity.
- Motor power, efficiency, and horsepower draw versus capacity.
- Pump Net Positive Suction Head Required (NPSHR) vs capacity.

Furnish 8 copies of certified performance curves and test reports for each pump before shipment. Report data in Standard English units.

4.3.12.2. **Field Testing**. Run field tests for the purpose of accepting the pumps for mechanical integrity. Submit a proposed test procedure to the Engineer for approval. Provide the necessary instrumentation.

Perform tests with potable water only. Providing water for the testing.

Tests must first establish that the pump H-Q curves are roughly tracking the factory test curves. At a minimum, five evenly spaced test points must be provided. These must include, while the pump is running at full speed: shutoff, full capacity, 1/2 capacity and two additional points as directed. Record motor amps and pressure for each point.

After determining that the pumps are performing per the factory H-Q curves, exercise the pumps for not less than one hour per pump. Demonstrate that pump, motor, and vibration does not exceed ANSI/HI limits and bearing temperatures do not exceed the manufacturer's recommendations. Vibration testing must be performed by a qualified independent testing agency.

Procure the services of an independent vibration testing agency to measure the vibration and the operating speed of the modified pumping unit under actual operating conditions.

Testing Agency Qualifications: Conduct testing in the presence of the Engineer. Testing must be conducted by a firm or individual whose qualifications are subject to the approval of the Engineer. Document testing results and submit to the Engineer for approval.

If any equipment fails the vibration tests, replace or adjust such until vibration falls within the specified limits. Replacement, adjustments, and retesting must be performed entirely at Contractor's expense.

4.4. **Flap Gate**. The Contractor must furnish labor, materials, and equipment required for installation of flap valves.

4.4.1. **Quality Assurance**.

The manufacturer must have at least 10 yr.' experience manufacturing flap valves and must show evidence of satisfactory operation in at least 5 installations. The company must be ISO 9001 certified.

Flap gates, wall thimbles, and related equipment must be designed, manufactured, and installed in conformance with the best practices and methods, and must operate satisfactorily when installed as shown on the plans.

Provide flap gates from a single manufacturer.

Furnish new and unused equipment that are standard products of manufacturers with a successful record of manufacturing and servicing the equipment and systems specified herein.

Manufacturer's Representative Services. Factory representative who has complete knowledge of proper operation and maintenance must be provided for at least one 8-hour day (exclusive of travel time) to instruct representatives of the Department on the proper operation and maintenance of the equipment. If there are difficulties in operation of the equipment due to the manufacturer's fabrication or the Contractor's installation, additional service must be provided at no change in Contract price or time.

4.4.2. **Submittals**.

The manufacturer must submit drawings showing critical dimensions, general construction, and materials used in the valve. Submittals must include the following:

- Complete description of materials.
- Certified shop and installation drawings showing details of construction, dimensions, and anchor bolt locations and sizes.
- Descriptive bulletins, and catalogs of the equipment.
- Complete bill of materials.
- A list of manufacturer's recommended spare parts with the manufacturer's current price for each item. Include gaskets, packing, etc. on the list. List bearings by bearing manufacturer's numbers only.
- Design calculations for the gate. Calculations must identify loading conditions, anchorage, and must verify that stresses and deformations will not impair operation and are within Specification requirements. These calculations must be stamped by a professional engineer licensed in the state of installation.

Operation and maintenance instructions. Provide a list of manufacturer's recommended set of spare parts and prices required for normal operation and maintenance.

Submit the following Test Reports:

- Description of test procedures and equipment.
- Copies of test results.

4.4.3. **Field Services and Warranty**. Provide services of manufacturer's representative onsite for installation inspection and field testing. Provide for the above services to be performed during separate visits to the project site. Notification of coordinating the site visits must be provided to the Engineer in writing at least 14 days in advance of each site visit. The Engineer reserves the right to reschedule each of the site visits with a 7-day period.

Each site visit must be confirmed in writing by a daily log signed by the Engineer and the Manufacturer's representative. Failure of the Manufacturer's representative to obtain a signature from the Engineer will result in the disqualification of the site visit made and will not be attributed to the completion of the total specified number of site visits.

After each installation, inspection, field testing, and start-up trip a written report covering the representative's findings must be submitted. Report must include inspection findings, field test results, installation approval, any deficiencies noted, and remedies for the deficiencies. Trip reports must be submitted within 3 days following the field service.

The manufacturer must warrant equipment manufactured by it to be free from defects in workmanship or material for a period of 2 yr. from date of conditional acceptance. If during said warranty period, any components prove to be defective in workmanship or material under normal use and service they will be replaced or repaired free of charge, inclusive of freight and labor.

4.4.4. **Delivery, Storage, and Handling**. Properly protect parts so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units are ready for operation. Properly protect equipment and parts against any damage during a prolonged period at the site. Factory assembled parts and components must not be dismantled for shipment unless permission is received in writing from the Engineer. Finished iron or steel surfaces not painted must be properly protected to prevent rust and corrosion. Do not ship equipment until approved in writing.

4.4.5. **Products**.

4.4.5.1. **General Design for Flap Gate**.

- Flap gates must open when there is a differential pressure across the flap of 6-in. or less.
- Flap gates must be substantially watertight under design load head conditions.
- Under the design seating head, the leakage must not exceed 0.10 US gallons per minute per foot of seating perimeter.
- Flap valve must have a cast iron body and cover.
- Seat and disc ring must be bronze, and the hinge pin and cotter pins must be stainless steel.
- Valve must be constructed with a 10° offset from vertical to ensure positive closure.
- The flange must be drilled using an ANSI 125# template.
- Iron parts must be coated in TNEMEC 2-part epoxy with 3-4 mils dry film thickness to prevent rusting or corrosion.
- The valve must be machined, assembled, and tested in the USA for quality assurance.
- The manufacturer must show proof of ISO 9001 certification.
- Valve and accessories must be manufactured by Troy Valve, Model A2540, Kenedy, or approved equal. Flap gate basis of design is Troy Valve. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the Contractor with no extra cost to the owner.

4.4.5.2. **Factory Inspection and Testing**. Perform factory inspection, testing, and correction of deficiencies in conformance with the referenced standards and as noted herein.

4.4.6. **Execution**.

4.4.6.1. **General**.

- Install appurtenances per the manufacturer's instructions in the locations shown, true to alignment and rigidly supported. Repair any damage to the above items to the satisfaction of the Engineer before they are installed.
- The Contractor must be responsible for the proper location of gates and appurtenances during the construction of the work.
- Carefully inspect materials for defects in construction and materials. Clean out debris and foreign material out of openings, etc. Check operating mechanisms for proper functioning and check nuts and bolts for tightness. Repair or replace equipment which does not operate easily, or is otherwise defective, at no additional cost to the Department.
- Where installation is covered by a referenced standard, perform installation in conformance with that standard, except as herein modified, and the Contractor must certify such. Also note additional requirements in other parts of this Section.
- Unless otherwise noted, make up joints for gates and appurtenances using the same procedures as specified under the applicable type connecting pipe joint and install gates and other items in the proper position as recommended by the manufacturer. Verify manufacturers' torquing requirements for gates.

4.4.6.2. **Inspection, Testing, and Correction of Deficiencies**. Before plant start-up, inspect items for proper alignment, quiet operation, proper connection, and satisfactory performance.

4.4.6.3. **Cleaning**. Inspect items including gate interiors before line closure, for the presence of debris.

4.5. **Ductless Split System Heat Pumps**. Provide split-system heat-pump unit consisting of separate evaporator-fan and compressor-condenser components. The split system heat pump must be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. The equipment must be constructed to the following standards.

4.5.1. **Action Submittals**. Submit the following for each type of product indicated.

- Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - Refrigeration piping system sizing and field configuration based upon actual equipment location and manufacturers specific requirements.
- Informational Submittals. Submit a sample of the special warranty.
- Closeout Submittals. Submit a copy of operational and maintenance data.

4.5.2. **Quality Assurance**.

- Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- ASHRAE Compliance:
- Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
- ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."
- ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

4.5.3. **Special Warranty**. Provide Manufacturer's standard form warranty in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period. Warranty should cover the following periods:

- For Compressor: Manufacturers extended warranty for 5 yr. from date of Substantial Completion.
- For Parts: 2 yr. from date of Substantial Completion.
- For Labor: 2 yr. from date of Substantial Completion.

4.5.4. **Wall-Mounted, Evaporator-Fan Components**.

- Cabinet: Enameled steel with removable panels on front and ends in color as shown in plans, and discharge drain pans with drain connection.
- Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
  - Fan: Direct drive, centrifugal.
  - Fan Motors:
- Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 “Common Motor Requirements for HVAC Equipment.”
    - Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
    - Retain first subparagraph below if enclosure is not open-drip proof type. Retain second subparagraph for premium efficiency.
    - Enclosure Type: Totally enclosed, fan cooled.

- NEMA Premium (TM) efficient motors as defined in NEMA MG 1.

- Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
    - Mount unit-mounted disconnect switches on exterior of unit.
- If unique characteristics are required for motors in this Section, insert subparagraphs below.
- Condensate Drain Pans:
    - Fabricated with 1% slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
    - Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
- Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
    - Minimum Connection Size: NPS 1.
- General Requirements for Air Filtration Section:
- Comply with NFPA 90A.
- Minimum MERV according to ASHRAE 52.2.
    - Filter-Holding Frames: Arranged for flat orientation, with access doors on both sides of unit. Filters must be removable from one side or lifted out from access plenum.
- Air-Cooled, Compressor-Condenser Components:
    - Casing: Steel, finished with baked enamel in color selected by Engineer, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
    - Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor must have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
        - Compressor Type: Scroll.
        - Refrigerant: R-410A.
- Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
- Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
- Fan: Aluminum-propeller type, directly connected to motor.
- Motor: Permanently lubricated, with integral thermal-overload protection.
- Mounting Base: Polyethylene.
- Accessories:
    - Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
    - Compressor time delay.
    - 24-hour time control of system stop and start.
- Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
- Fan-speed selection including auto setting.
    - Automatic-reset timer to prevent rapid cycling of compressor.
- Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

4.5.5. **Execution**.

- Installation and Demonstration. Install the split system heat pump level and plumb. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

Install ground-mounted, compressor-condenser components on polyethylene mounting base.

Field Quality Control. Perform tests and inspections. Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

- Tests and Inspections:
  - Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - Prepare test and inspection reports.
- Demonstration. Train Department's maintenance personnel to adjust, operate, and maintain units.

4.6. **Sidewall Propeller Fans**. Provide wall-mounted propeller fan meeting the following requirements.

4.6.1. **Action Submittals**,

- Product Data: For each type of product.
  - Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
- Rated capacities, operating characteristics, and furnished specialties and accessories.
- Certified fan performance curves with system operating conditions indicated.
  - Certified fan sound-power ratings.
  - Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - Material thickness and finishes, including color charts.
- Dampers, including housings, linkages, and operators.
- Shop Drawings:
  - Include plans, elevations, sections, and attachment details.
- Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - Include diagrams for power, signal, and control wiring.
  - Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

4.6.2. **Informational Submittals**.

- Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.
- Seismic Qualification Data: For fans, accessories, and components, from manufacturer.
- Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- Field quality-control reports.

4.6.3. **Closeout Submittals**. For centrifugal fans to include in normal operation, provide emergency operation, and maintenance manuals with replacement parts listing.

4.6.4. **Maintenance Material Submittals**. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

4.6.5. **Products**.

General.

- Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
- Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.
- Belt Drives:
  - Resiliently mounted to housing.
  - Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
  - Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
- Accessories:
- Bird Screens: Removable, 1/2-in. mesh, aluminum, or brass wire.
  - Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
  - Spark-resistant, all-aluminum wheel construction.

4.6.6. **Installation and Demonstration**.

- Wall-mounted propeller fans must be installed using the following criteria:
  - Install power ventilators level and plumb.
  - Install units with clearances for service and maintenance.
  - Label units according to requirements specified in this Item.
- Engage a factory-authorized service representative to perform start-up service.
- Complete installation and start-up checks in conformance with manufacturer's written instructions.
- Verify that shipping, blocking, and bracing are removed.
- Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
- Verify that cleaning and adjusting are complete.
- For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
- Adjust belt tension.
- Adjust damper linkages for proper damper operation.
- Verify lubrication for bearings and other moving parts.
- Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
- Disable automatic temperature-control operators, energize motor, and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
- Shut unit down and reconnect automatic temperature-control operators.
- Remove and replace malfunctioning units and retest as specified above.
- Train Department's maintenance personnel to adjust, operate, and maintain centrifugal fans.

4.7. **Fixed Louvers**. Provide wall-mounted louver meeting the following requirements.

4.7.1. **Action Submittals**.

4.7.1.1. **Product Data**. For each type of product, provide the following.

- Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans;
- Rated capacities, operating characteristics, and furnished specialties and accessories; and
- Material thickness and finishes, including color charts.

4.7.1.2. **Informational Submittals**. Provide sample of special warranty.

4.7.1.3. **Closeout Submittals**. Provide operation and maintenance data.

4.7.2. **Products: Louvers**. Provide fixed extruded aluminum louvers.

Horizontal, Continuous-Line, Drainable-Blade Louver, Extruded Aluminum: Drainable-blade louver with blade gutters (drains) in rear two-thirds of blades only.

- **Louver depth**: 6 in.
- **Frame and Blade Nominal Thickness**: Not less than 0.080 in. (2.03 mm).
- **Mullion Type**: Semi-recessed.
- **Louver Performance Ratings**:
- **Free Area**: Not less than 7.8 sq. ft. for 48-in. wide by 48-in. high louver.
- **Point of Beginning Water Penetration**: Not less than 850 fpm.
- **Air Performance**: Not more than 0.10-in. wg static pressure drop at 800-fpm free-area intake velocity.
- **AMCA Seal**: Mark units with AMCA Certified Ratings Seal.
- **Finish**: As selected by architect from manufacturer's full range.

4.7.3. **Execution**.

4.7.3.1. **Examination**. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the work. Proceed with installation only after unsatisfactory conditions have been corrected.

4.7.3.2. **Preparation**. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

4.7.3.3. **Installation**. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

Form closely fitted joints with exposed connections accurately located and secured.

Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with joint for sealants applied during louver installation as indicated on the plans and this Specification.

4.7.3.4. **Adjusting and Cleaning**. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

4.8. **General Electrical Provisions.**

4.8.1. **General**. Perform electrical work in conformance with the applicable codes, standards, and ordinances including, but not limited to, National Fire Protection Association (NFPA), International Building Code (IBC), Underwriter's Laboratory (UL).

Employ a master electrician, licensed in the State of Texas to directly supervise the Contractor forces.

Provide electrical submittals that are certified correct by the master electrician. Ensure persons performing electrical work have an appropriate electrical license.

Provide documentation that proves the Contractor has at least 5 yr.' experience and is qualified in this type of scope and work.

Install electrical service as shown on the plans and as required by the electrical utility company. Provide temporary electrical equipment, materials, and service necessary for constructing the pumping station, including any for dewatering.

Provide electricians to make necessary connections of the portable load banks to the load lugs of the generator or generator main breaker for the required generator set testing.

The Electrical Contractor must provide labor, materials, equipment, and services for a complete electrical system required for this Contract including, but not limited to:

- Coordination of connections and providing conduits for work required for the electrical service.
- Electrical equipment and building grounding systems.
- Electrical connections complete to equipment whether indicated on the plans or not.
- Motor starters and disconnects as required by the National Electrical Code. Provide power wiring from panel to disconnect or starter and to motor or equipment. Wire line voltage controls carrying motor or equipment power.
- Support systems for electrical work.
- Cutting and patching as required for electrical work.
- Temporary electrical service if required during construction.
- Testing of electrical systems.
- Coordinate work with Control System Supplier and provide related conduit and wiring for power and controls.
- Motor Control Center, automatic transfer switches, transformers, and required distribution equipment and associated feeders, and standby power system.
- Station lighting systems.
- Pump power, control, and alarm wiring.
- Wiring, conduit, and other equipment, whether shown on the plans or specifically mentioned in the Specifications or not, to accomplish a fully functional electrical system.

4.8.2. **Submittals**. Submittals must include enough data to make a thorough evaluation of features, construction, and performance.

Materials, equipment, and fixtures must completely satisfy Specification requirements and be suitable for their intended use. Items of equipment submitted must include accessories and options recommended by the manufacturer for satisfactory, reliable, and safe operation in its designated location.

Manufacturer's model and catalog numbers change frequently and may not necessarily include specified or required features and may not ensure compatibility with supporting systems or intended application. Ensure that material and equipment delivered to the jobsite is suitable for the intended application and indicated connections. Review of shop drawings must not include review and verification of submitted catalog numbers or quantities required.

Ship or fabricate equipment in sections of suitable size for entering building and necessary arrangements for their installation must be made by the Contractor.

Shop drawings and submittals must bear the General Contractor's review and approval stamp before submission to the Engineer.

Submit copies of shop drawings for electrical equipment custom made for this Contract. Drawings must be revised as directed and resubmitted.

Submittals must show physical size and arrangement of equipment, wiring diagrams for equipment showing circuit devices, and elementary control diagrams in straight-line form for motor control equipment.

Cleary indicate in submittals which products are to be provided as part of this project.

Submit conduit layout proposed for the project for review and approval before installation.

4.8.3. **Materials**. Supply new materials listed by the Underwriters Laboratories, Inc., or locally approved national testing agency as conforming to standards in every case where such a standard has been established for a particular material in question. Equipment must be packaged in their original containers.

Furnish equipment or materials for any one system by the same manufacturer. Such items include conduit, wire, motor control center, wiring devices, etc.

Materials installed on exterior of buildings must be weathertight and of such design as intended for this purpose.

Install equipment in strict conformance with manufacturer's instructions for type, capacity, and suitability of each piece of equipment used. Install equipment in conformance with manufacturer's recommendations and meet conditions of manufacturer's standard warranty.

Protect work, materials, or equipment which are liable to cause injury during construction period. Securely cover or otherwise protect openings into any part of conduit system as well as associated fixtures, equipment, both before and after being set in place to prevent obstruction of conduit or injury due to carelessness or maliciously dropped tools or materials, grit, dirt, or any foreign matter. Contractor is responsible for damage so done until his work is installed and accepted. Cover conduit ends with capped bushings.

Furnish minimum 4 in. thick or as noted, reinforced concrete housekeeping pads to extend 6 in., or as noted on the plans, beyond equipment for free-standing electrical distribution equipment.

Provide accessories, equipment and connections required for complete installation, ready for continuous use.

Perform NETA Acceptance tests on each piece of equipment installed for this project. Tests labeled as optional are not required to be performed. Give timely notice of intention to test work to permit observation. Obtain the services of an independent NETA Member Testing Agency to perform testing. The Testing Agency must test the entire electrical system in conformance with current procedures stated in Acceptance Testing Specifications published by the National Electric Testing Association. Furnish equipment necessary to conduct such test at the Contractor's expense.

4.8.4. **Coordination with Other Trades**. Confer with other trades whose work might affect installation and arrange work in proper relation to that of others.

Where interferences occur, Contractor must, before installing work involved, consult with the Engineer and other trades to reach agreement as to exact location and level of work, and submit agreed upon layout for approval before starting this work.

Contractor is responsible for arrangement of work, equipment, and maintenance of proper clearances for installation. Should work installed require modification to avoid interference, such changes must be made without additional cost.

If work is dependent for its proper execution on contiguous work not specified, examine such work and report in writing any defects therein or conditions rendering it unsuitable. Beginning of work without making of such a report must constitute an acceptance of work, and any subsequent defects in his work consequent must be the Contractor's responsibility.

4.8.5. **Permits**. Obtain permits, licenses or pay fees not otherwise identified under provisions of general conditions of this Contract Specification.

4.8.6. **Guarantee**. Unless otherwise specified, unconditionally guarantee for a period set forth in the General Conditions, but not less than 2 yr., materials, workmanship, and installation. During this period, adjust, repair, or replace at no cost to the Department any item of equipment or workmanship found to be defective. Contractor will be responsible for and pay for damages cause by or resulting from defects in workmanship.

4.9. **Electrical Testing**.

4.9.1. **Submittals**.

Qualification Data: For testing agency, submit company profile, listing of 10 similar projects performed in the last 2 yr. including contact information as references, and company and employee qualifications and certifications.

Final Equipment Test Report: After specified field inspection, testing and evaluation are completed, submit for approval the final equipment test report. Each equipment test report must be clearly labeled with whether the equipment passed or failed the test.

Project work Schedule: Coordinate project work schedule with the Engineer and submit for approval before start of work.

4.9.2. **Quality Assurance**.

The testing agency must be a single independent agency, with the experience and capability to conduct the required inspections and testing indicated that is a current full member company of the International Electrical Testing Association (NETA), and that is acceptable to the Authorities Having Jurisdiction (AHJ). Companies that are not a current full member company of NETA will not be permitted to bid on or perform this work. Persons performing inspection and testing functions must be permanently employed by the single independent agency. The testing agency's field supervisor must be a person currently certified by NETA to supervise onsite testing specified in these Specifications.

The testing agency must have an up-to-date equipment calibration program. Test equipment used must be currently calibrated. Submit certifications of calibration for any equipment.

Before submitting the bid, the Contractor must visit the site and be thoroughly familiar with the existing conditions. Any errors, discrepancies, or missed items must be brought to the attention of the Engineer during the bidding process. No additional cost will be allowed for any discrepancy that could have been noticed at the site visit by the Contractor.

4.9.3. **Project Conditions**. This work will be performed in an existing operational facility. Perform work in conformance with the Department's schedule requirements to provide minimal impact to the building operations.

4.9.4. **Execution**. Inspection and Electrical Testing: Perform visual and mechanical inspections and electrical tests in conformance with applicable sections of the latest edition of the NETA Acceptance Testing Specifications (ATS) and in conformance with manufacturer recommendations for electrical equipment that is installed as part of this project. Optional tests referred to in the NETA ATS are not required. Return equipment to safe operational condition after inspections and electrical tests are completed.

Final Equipment Test Report. Prepare and submit for approval a written Final Equipment Test Report including the results from inspections, electrical testing, and power system data collection. The report must include, but not be limited to the items listed below. Submittals received without the information listed below will be rejected in their entirety and will not be reviewed.

- Cover Sheet: Typed, including project name, project location, testing agency name, and date.
- Summary of results: Typed, summarizing inspection results, test results and recommendations for any required corrective actions. Note: equipment must be evaluated. Equipment must be noted as being acceptable or requiring corrective action (with recommended corrective action noted).
- Letter from the testing agency stating that equipment included in the report has been tested and evaluated in conformance with applicable NETA recommendations.
- Equipment inspection and test data sheets including the following: Date of Test, Equipment designation, field inspection and test data including NETA required information, Clear Pass/Fail indication on each sheet for each piece of equipment, recommended corrective action for any discrepancies, deficiencies or other as-found conditions requiring repair.

4.10. **Overcurrent Protective Devices Coordination and Arc Flash Study**. This Section includes computer-based, fault-current and overcurrent protective device studies, and the setting of these devices. This section also includes completion of an arc flash study. The studies and reports must include the electrical system from the utility company service entrance down to and including proposed and existing to remain MCC's, panelboards, motors, automatic transfer switches, disconnect switches, generators, and any other major distribution system equipment. The studies and reports must address possible system switching configurations and alternate operating conditions that could result in maximum fault current conditions or worst-case incident energy levels.

4.10.1. **Submittals**.

- Product Data: For computer software program to be used for studies;
- Qualification Data: For coordination Study Specialists;
- Action Submittals;
- Coordination-study input data, including documentation from the utility company stating the available fault current at the service entrance; and
  - Coordination-study report
  - Short Circuit evaluation report for equipment.
  - Settings report for adjustable trip devices.
  - Arc Flash study report.

- Arc Flash warning labels for use in the field.

4.10.2. **Quality Assurance**. Studies must use computer programs that are distributed nationally and are in wide use. Software algorithms must comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

Coordination-Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices for at least 3 yr.. Submitted study must be stamped and signed by a professional engineer licensed in the state of Texas.

Comply with IEEE 399 for general study procedures. Comply with IEEE for short-circuit currents and coordination time intervals.

4.10.3. **Products**. Perform the studies using one of the following software packages: SKM or ETAP.

4.10.4. **Execution**.

4.10.4.1. **Examination**. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study. Studies must be based on equipment approved for use on this project. Perform site survey to obtain any additional information that is not shown on the plans required to complete the specified studies. Coordinate with the local utility for site specific available fault-current data.

4.10.4.2. **Fault-Current Study**.

- Source Impedance: Utility Company's fault-current contribution. Coordinate with the local utility for site specific fault current data.
- Study electrical distribution system from normal and alternate power source throughout electrical distribution system for project and use approved computer program to Eq values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions. Study and report must include the electrical system from the utility company service entrance down to and including MCC's, panelboards, motors, automatic transfer switches, disconnect switches, generator, and any other major distribution system equipment.
- Calculate momentary and interrupting duties on the basis of maximum available fault current.
- Calculations to verify interrupting ratings of overcurrent protective devices must comply with the following:
  - Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50
  - Low-Voltage Fuses: IEEE C37.46
  - Circuit Breakers: IEEEC37.13
  - Other Equipment: As Applicable
- Study Report: Enter calculated X/R ratios and interrupting fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2 Cycle), interrupting, and 30-cycle fault-current values for 3-phase, 2-phase, and phase to ground faults.
- Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault current momentary and interrupting duties.

4.10.4.3. **Coordination Study**. Gather and tabulate the following input data to support coordination study.

- Product data for overcurrent protective devices. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings;
- Impedance of utility service entrance;
- Circuit breaker and fuse current ratings and types;
- Transformer kVA, primary and secondary voltages, connection type, impedance, and X/R ratio;
- Cables including conduit material, sizes of conductors, conductor material, conductor insulation, and length;
- Motor horsepower and code letter designation according to NEMA MG 1; and
- Data sheets to supplement electrical distribution system diagram, cross referenced with tag numbers on diagram.

Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399. Provide recommended settings for adjustable overcurrent protective devices including, but not limited to the generator. Provide time current curve for the devices.

Comply with NFPA 70 for overcurrent protection of circuit elements and devices. Comply with IEEE 141 and IEEE 242 recommendations for fault currents and time intervals.

Transformer Primary Overcurrent Protective Devices: Devices must not operate in response to full load current or permissible transformer overloads in accordance with IEEE C57.96.

Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

Prepare a report indicating the following results of the coordination study:

- Tabular format of settings selected for Overcurrent Protective devices including device tag, relay current transformer ratio, circuit breaker sensor rating, long time, short time and instantaneous settings, and ground fault relay pickup and time delay settings.
- Coordination curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Curves must show device tag, voltage and current ratio for curves, three phase and single phase damage points for transformers, cable damage curves, transformer inrush points, maximum fault current cutoff point.
- Completed data sheet for setting overcurrent devices.

4.10.4.4. **Overcurrent Protective Device Setting**. Engage a qualified testing agency to perform the device setting and to prepare test reports. After installing overcurrent protective devices and during energizing process of electrical distribution system, verify that the overcurrent protective devices meet parameters used in studies. Adjust devices to values listed in study results.

4.10.4.5. **Arc Flash Study**. Perform an arc flash study in conjunction with the previous specified fault current and protective device coordination study. Perform study in accordance with IEEE 1584.

The study must be calculated using an approved computer software program. Pertinent data and the rational employed in developing the calculations must be incorporated into the introductory remarks of the study. The study must include the electrical system from the utility company service entrance down to and including

MCCs, panelboards, motors, automatic transfer switches, disconnect switches, enclosed circuit breakers, generator, and other major distribution equipment.

Determine the following for each bus analyzed.

- Flash Hazard Protection Boundary,
- Incident Energy Level,
- Required Personal Protective Equipment (PPE) Category,
- Type of Fire Rated Clothing,
- Limited Approach Boundary,
- Restricted Approach Boundary, and
- Prohibited Approach Boundary.

Produce an Arch Flash warning label for each piece of electrical equipment that includes a specific equipment ID. Also include the system operating voltage and date of study. Labels must be printed in color on adhesive backed nylon labels. Sample label must be submitted for approval before installation. Labels must follow lates NFPA requirements.

Prepare a written report indicating the following results in tabular format.

- Flash Bus Name,
- Protective Device Name,
- Bus Operating Voltage,
- Bus bolted fault current,
- Protective device bolted fault current,
- Protective device arcing fault current,
- Trip/delay time,
- Breaker opening time,
- Ground,
- Equipment type,
- Gap (mm),
- Arc Flash Boundary (in.),
- working Distance (in.),
- Incident energy (cal/sq.cm), and
- Required Personal Protective Equipment.

The electrical contractor must permanently affix the arc flash warning labels to each piece of electrical equipment including, but not limited to, motor control centers, panelboards, automatic transfer switches, disconnect switches, enclosed circuit breakers, and any other major distribution system equipment.

4.11. **Electric Materials and Methods**.

4.11.1. **Products**.

- Raceways and Fittings. For underground conduit, use PVC Schedule 80, heavy wall, UL listed. Provide at least 3 in. of clearance between conduits and at least 24 in. of cover or as noted on the plans. Use galvanized rigid metal conduit (RMC) for exposed conduit.
- Grounding System Devices and Equipment: Ground rods must be 3/4 in. x 10 ft., copper clad steel.
- Ground rod and cable connections underground: Exothermic weld such as Cadweld or ThermOweld.
- Boxes: Manufactured pull boxes must be one piece stamped galvanized steel, machine screw fasteners with ground bond screw, UL listed.

- Direct burial handholes must be constructed of reinforced fiberglass with a cover rated for “heavy duty” traffic. Size must be as specified or as required by code, whichever one is larger. Provide by Quazite, Armorcast, or approved equal. Conduit fittings must match conduit type.
- Outlet, junction, and switch boxes must be cast, Type FS or FD. Cast boxes must be by Appleton, Hubbell, Killark, Thomas & Betts, or approved equal.
- Group surface mounted devices in multi-gang cast box. The size must be governed by the intended use.
  - Exterior wall surfaces or otherwise exposed to weather must be cast FD boxes with threaded hubs and UL Listed.
  - Pull boxes: construct of code gauge galvanized sheet steel with screw cover.
  - Where installed below the operating level slab, in damp or wet locations, or outdoors, boxes must be Type 316 Stainless Steel, NEMA 4X.
- Conductors
- Provide wire and cable that is UL listed, 600-Volt Type XHHW with 75°C rating.
- Provide insulation in accordance with the latest edition of ICEA S-68-516, NEMA WC-8, UL 44, and IEEE 383.
- Supply conductors that are soft annealed copper per ANSI/ASTM B-8, Class D, stranded.
  - The minimum allowable size of wire and cable is No. 12 AWG for power and No. 14AWG for control.
  - Use heat shrink tubing with sealant to seal any splices in wet wells.
  - Wire Connectors: For connections of one or more No. 10 AWG or smaller, solderless twist-on connectors must be used. The connectors must have an outer insulating shell manufactured from nylon material and must be formed with “S”-shaped fins to improve twisting. The spring insert must be a helical elongated coil formed from square spring steel to cause the spring to have “live action” and reduce turning friction. The connectors must be rated flame and heat retardant for up to 105°C maximum and be listed for UL 486. Conductors No. 8 AWG and larger must be terminated, spliced, or tapped wherever practicable with Thomas & Betts color keyed series 54000 tool applied compression connectors or approved equal.
  - Terminations: Belleville type compression washers must be used when ambient temperature exceeds 30°C, T&B Series 60800, STS Industrial, or equal.
- Compression tools: Make compression connectors with manufacturers recommended tool incorporating a rachet release type mechanism to ensure complete compression.
- Provide wire fastening products where wiring is required to be secured. Wire fastening products must include but not be limited to the following components: natural nylon cable ties, black (UV-resistant) cable ties, cable tie mounts, adhesive cable tie mounting pads, adhesive press clips, molded nylon clamps, molded polypropylene clamps, flat nylon clamps, and adhesive-mount adjustable clamps.
  Use pulling lubricants on raceway wiring. Pulling lubricants must be of a greaseless compound, non-corrosive, non-conductive, non-combustible, non-toxic, for use with PVC or steel raceways and safe for use on UL-listed wire insulation. The pulling lubricant must be Quick-Slip by Buchanan, Ideal, or approved equal.
- Supporting Devices
  - Secure materials to the structure by inserts cast in concrete, expansion anchors in concrete block, machine screws or bolts on metal surfaces. Hardware must be Type 316 stainless steel. Hangars must be as follows:
    - Channel: Type 316 stainless steel by Kindorf, Unistrut, Globe Strut, or B-Line.
    - Channel Fittings: Type 316 stainless steel by Kindorf, Unistrut, or B-Line.
    - Conduit Hangars: Type 316 Stainless steel clevis type by Unistrut, Kindorf, or Grinnell.
    - Wall Anchors: Expansion bolt, toggle bolt, or other approved structural anchor. Hardware must be Type 316 stainless steel.
  - For electrical materials and components secured to joists, fasten to the top member of the joist.

4.11.2. **Execution**.

4.11.2.1. **Preparation**. Check door swings and clearances with equipment, cabinets, appliances, and coordinate with plans and Specifications before performing work.

4.11.2.2. **Installation**. Exposed wiring and conduit must be installed in a neat and workmanlike manner with runs plumb and parallel to walls. Bends and offsets must be avoided where possible, but where necessary must be made with an approved conduit bending machine. Conduit or tubing which has been crushed or deformed in any way or has begun to rust must not be installed. Use expansion bolts to secure equipment, conduit, or devices. Conduits or tubing must be supported on approved types of stainless-steel wall brackets, ceiling trapeze or pipe straps, secured by means of expansion bolts in concrete or brick. Nails must not be used as a means of fastening surface boxes or conduits. Conduit or tubing must be installed in such a manner as to ensure against trouble from collection of trapped condensation and runs on conduit must be arranged as to be devoid of traps wherever possible.

Raceways must meet requirements of the National Electrical Code and local codes.

Liquid-tight flexible metal conduit must be used for connections to motors and other electrical equipment subject to movement or vibration. Maximum length must not exceed 3 ft.

Wire and cable must be continuous without splicing from load to source to supply. Splicing must only be performed after obtaining written approval.

Wire and cable, including grounds, must be run in conduit unless written permission is obtained.

Provide clamps made of stainless steel. Multiple runs of conduit must be supported on metal channel with conduit clamps. Trapezes must be metal channel with conduit clamps.

Penetrations through concrete walls, floors, and footings, both interior and exterior must be sleeved and caulked with grout or plastic compound to provide watertight seal.

Bends must be kept in conformance with minimum recommended by manufacturer. Cables must be paralleled on reels and be pulled directly into raceway from the coils or reels on which they are received. Cable must not be laid on the ground.

Use pulling lubricants on raceway wiring. Wire and cable must be installed only after raceways are free of obstruction and clean. Wires must be color coded. Wiring must be tagged with Brady “Quick” labels at terminations with each individual wire with a unique identifying number. Wiring in panelboards and terminal cabinets must be neatly trained and served.

Install empty conduits complete with a nylon pull cord.

4.12. **Service Distribution**. Install complete electrical distribution system, underground conduits and trenches, and backfill as required. Perform infrared testing of motor control center, panelboards, VFD’s, and automatic transfer switch.

4.12.1. **Submittals**. Submit cut sheets on items of electrical equipment. Include panelboards, switches, wiring, receptacles, motor starters, disconnect switches, wiring devices, cover plates, nameplates, distribution equipment and overcurrent devices.

4.12.2. **Infrared Testing**. Employ an independent certified testing laboratory to inspect and test the motor control center, panelboards, and automatic transfer switches. Perform infrared tests to determine that the terminations are tightened to proper torques and that no part of the equipment is overheating beyond normal operating conditions. Perform this test twice, once at one week after substantial completion of the project.

4.12.3. **Products**.

4.12.3.1. **Lighting Panelboard**. Provide the lighting panel with circuit breakers that have the capacity indicated on the plans. Locate the top operating handle a maximum of 6.5 ft. above the finished floor. Provide typed panel directory in panel. Incorporate panel as an integral part of the Motor Control Center.

4.12.3.2. **Circuit Breakers**. Thermal magnetic type, tripping free of handle. Handle must have three distinctive positions: “OFF”, “ON”, and “TRIPPED.” Provide solid state trip units where indicated on plans.

4.12.3.3. **Thermal-Manual Motor Starters**. Unless otherwise indicated on the plans, thermal-manual motor starters must be line-voltage type with thermal over-load protection and red “run” pilot light. Thermal Manual starters must be quick make and break, toggle operated, trip free, and must be provided with lock off handle guard. Where required for automatic operation by a remote pilot device, thermal-manual motor starters must be provided with a “hand-off-automatic” selector switch, in addition to the “on-reset-off” toggle switch. Thermal-manual motor starters must be wall mounted with stainless steel plates. Thermal manual motor starters must be rated 30 amps, Square D Class 2510, Eaton, or approved equal.

4.12.3.4. **Magnetic Motor Starters**. Magnetic motor starters must be full voltage; horsepower rated, across the line starting with 120V control. Provide 120V control transformer with fused secondary. Motor starters must be NEMA rated. Provide green “run” and red “stop” pilot lights mounted in cover. Pilot lights must be provided with factory-finished legend plates indicating “stop,” “run,” etc. Pilot lights must be provided with interlocks controlled by the starter operating coil.

Provide Solid State Overload Relays with the following features.

- Switch or dial selectable for motor running overload protection,
- Sensors in each phase, and
- Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

Provide reset button, run time meter, start counter, and Hand-Off-Automatic switch for each starter. Items must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the enclosure.

For each starter, provide at least 4 auxiliary spare contacts (2 N.O. and 2 N.C.) for interlocking and automatic operation. Contacts must also be convertible from N.O. to N.C.

Three-phase starters must have phase monitors that must automatically shut down the load during single phase conditions.

4.12.4. **Wiring Methods**. Branch circuit wiring for switches, lighting, and receptacles must be exposed on walls and ceilings. Wiring must be supported in conformance with provisions in the National Electrical Code and local code requirements and must use approved fasteners and clamps. Conduits secured to walls must be fastened to wall studs where spacing permits. In any case, conduits and clamps must be rigidly secured and free of obstruction which may cause injuries.

Conductors must be color coded.

- 480/277V System: Brown, Orange, Yellow;
- 208/120V System: Black, Red, Blue;
- Neutral: White; and
- Ground: Green.

No. 8 AWG or larger conductors must have NEC required color coding as:

- Solid color compound or solid color coating; and

- Colored, pressure sensitive plastic tape. Tape must be applied in half overlapping turns for at least 3 in. for terminal points, and in junction boxes, pull boxes, troughs, manholes, and handholes. Tape must be 3/4-in. wide with colors as specified above. The last two laps of tape must be applied with no tension to prevent possible unwinding.

4.12.5. **Wiring Devices**. Light Switches must be extra hard use, commercial premium specification grade and comply with Federal Specification W-S 896B and rated 20 amps and voltage as dictated by the system. They must be approved for control motors up to 80% of the switch rating and must be quiet AC type. Use single pole, double pole, 3-way, or 4-way as shown.

Receptacles must be extra hard use, commercial premium specification grade, two pole, three wire, and straight blade type and must comply with Federal Specification W-C 596E with a rating of 20 amperes for single receptacle circuits or as indicated on the plans.

Outlets and switches must be brown in color.

Ground fault interrupter devices must be duplex receptacle type and must comply with UL standard 943, class A. They must be no more than 1 1/8 in. deep with standard terminal screw connections and feed-through capability rated at 20 Amps.

Receptacles must have weatherproof boxes with while-in-use covers. Switch and other device plates must be stainless steel. Depth must be suitable for sump-pump plug.

Emergency stop push buttons must be snap-type, maintained-contact mushroom style switches, by Allen Bradley 800 series, Square D, or approved equal.

4.12.6. **Connections to Mechanical Equipment**. Carefully make a note other equipment requiring electrical power to be furnished to fully understand wiring and motor starting requirements.

Furnish and install an enclosed disconnect switch and motor starter for each motor installed unless specifically indicated as furnished with the equipment.

Furnish and install power wiring for motors complete from Motor Control Center or panelboard, through motor starter, to motor terminations.

Provide disconnect switches where shown on the plans or as required by the NEC, fused or unfused as required, Heavy Duty and must be Square D Class 3110, Eaton, or approved equal. Any switch installed outdoors or below grade level in the pump station must be rated NEMA 4X and must be Type 316 stainless steel. Provide option to allow locking in open and closed position.

4.12.7. **Fuses**. Coordinate fuse ratings with utilization equipment limitations of maximum fuse size. Furnish and install three extra fuses of each type and rating used.

Subject to compliance with requirements, supply fuses from one of the following manufacturers.

- Cooper Bussman,
- Feral Shawmut, and
- Littlefuse.

Cartridge fuses: Provide NEMA FU1, non-renewable cartridge fuses, class and current rating indicated; voltage rating consistent with circuit rating.

Fuse Applications:

- **Motor Branch Circuits**: Class RK1, time delay; and
- **Other Branch Circuits**: Class RK1, time delay.

Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

Install labels indicating fuse replacement information on inside door of each fused switch.

4.12.8. **Motor Starters and Controls**. Install items in conformance with manufacturer's instructions. Provide interlocks, contacts, pilot lights, and Hand-Off-Auto switches for starters. Provide starters, push buttons, etc. Mount motor starters on wall and install suitable stainless-steel enclosures and cover plates. Set overload devices to suit motors provided. Connect motors with maximum 3-ft. length of liquid tight flexible metal conduit at the motor connection.

4.12.9. **Grounding**. Provide ground bond to cold water services and to ground rods. Bond non-current carrying metallic parts of equipment, mechanical systems, and building steel. Neutral conductor at main switches must be grounded. Ground bus must not be less than size required by National Electrical Code and local codes. Grounding system must be complete and installed in conformance with local jurisdictions requirements. Ground rods must be copper clad steel, driven as indicated. Where soil conditions are poor, notify the Engineer so that supplemental grounding may be considered. Ground and bond piping systems and building steel within building as required by the NEC.

Temporary Service: The Contractor must make the necessary arrangements and provide temporary electric service and lighting required during the entire construction period. The metered costs of electricity used must be borne by the Contractor upon final acceptance. The electric service must be of enough capacity and characteristics to supply the proper current for the various types of construction tools, motors, welding machines, lights, heating plant, pumps, and other work required. Provide the necessary temporary wiring, panelboards, outlets, switches, lamps, fuses, controls, and accessories. Exact location of temporary service delivery point must be agreed upon by utility company and Department. Contractor's installation of temporary service must comply with applicable codes and regulations and must include ground fault interrupters.

Power Company Coordination: Contractor must provide site facilities as per power company's requirements. Contractor must not do any rough-in of empty conduits, transformer pads, meter sockets, etc. until the utility company has produced engineered drawings indicating exact locations and conduits required.

4.12.10. **Execution and Installation**. In general, install switches and receptacles in locations shown on the plans. Conduit and wiring for switches and receptacles must be exposed on walls. Study general building plans in relation to space surrounding each device in order that intended work may accommodate other specific work and must make minor adjustments as needed. Install boxes in a rigid and satisfactory manner. Support boxes independent of raceways. Adjacent wall mounted wiring devices, room thermostats, or other equipment must be coordinated so located either at the same elevation or in line, one above the other. Install conduit, outlets and equipment to clear beams or obstructions. Do not cut into or reduce the size of any load-carrying member without the approval of the Engineer. Obtain permission of Engineer before cutting any existing structure concrete walls or floors. Check drawings and work of others to prevent interference. Perform deviations of work to avoid obstructions as determined without additional cost.

Ground equipment in conformance with the National Electrical Code requirements and utility company requirements.

Mounting heights, unless otherwise specified:

- **Receptacles**: 48 in. above finished floor, and
- **Wall Switches**: 48 in. above finished floor.

Wiring devices must be wired using the screw terminals. Push connections are not acceptable.

Support pull boxes and junction boxes in ceiling from structure and not from raceways or ceiling suspension system.

Use locknuts and insulating bushings at rigid conduit ends at junction boxes, pull boxes, panel, starters, disconnect switches, and other boxes.

Protect conduit openings and do not pull wire until work which would damage wire has been completed near ends of conduit. Furnish empty raceways with nylon pull strings.

Bend conduits with a conduit bender, where bends are necessary.

When cutting conduit, square ends, thread, ream, and clean.

Use gasketed covers and threaded raceway hubs for exterior raceway connections. Use vandal resistant hardware at outdoor locations.

Label safety switches, disconnect switches, motor starters, and other equipment with engraved laminated plastic tags, not smaller than 3/8 in. high, indicating function served. Letters must not be smaller than 1/4 in. high and must be black on white background. Submit proposed designations and sample for approval.

4.13. **Grounding**. Secondary service neutrals must be grounded at the supply side of the secondary disconnecting means and at the related transformers. Ground metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in proximity with electrical circuits for personnel safety and to provide a low impedance path for possible ground fault currents.

4.13.1. **Submittals**. Submit catalog cut sheets and descriptive literature for approval in accordance with Article 3., Operations and Maintenance Manuals. Include enough information clearly presented to determine compliance with plans and specifications.

- **Submittals**: Ground Rods, connectors, and exothermic welding system;
- Submit and certify test reports from the NETA approved testing agency of ground resistance to the Engineer. Reports must indicate date, time, temperature, and equipment used for ground resistance testing, by manufacturer and model number; and
- Test grounding systems in conformance with NETA standards and summarize in the report.

4.13.2. **Products**. Ground wires must be UL and NEC approved types, copper, with green insulation, except where otherwise shown on the plans or specified.

4.13.3. **Execution**. Connect the secondary service neutral to the ground bus in the service equipment. Provide a ground loop with at least three ground rods and foundation ground connection and connect to the service equipment ground bus.

4.13.3.1. **Service Entrance Motor Control Center**. Provide a ground bar bolted to the enclosure with lugs for connecting the various grounding conductors. Connect the various feeder green grounding conductors to the ground bus in the enclosure with suitable crimped pressure connectors. Connect the grounding electrode conductor to the ground bus. Connect the neutral to the ground bus. Connect metallic conduits, which terminate without mechanical connection to the housing, by grounding bushings and ground wire to the ground bus.

4.13.3.2. **Conduit Systems**. Ground metallic conduit systems. Conduit systems must contain a grounding conductor. Metallic conduit provided for mechanical protection and containing only a grounding conductor must be bonded to that conductor at the entrance and exit from the conduit. Use grounding bushings for feeder conduits attached through concentric knockouts regardless of system voltage.

4.13.3.3. **Feeders and Branch Circuits**. Install green grounding conductors with feeders and branch circuits.

4.13.3.4. **Boxes, Cabinets, Enclosures, and Panelboards**. Bond the grounding wires to each pull box, junction box, outlet box, cabinets, and other enclosures through which the ground wires pass. Provide lugs in each box

and enclosure for ground wire termination. Provide ground bars in panelboards, bolted to the housing, with enough lugs for terminating the ground wires.

4.13.3.5. **Motors and Starters**. Provide lugs in motor terminal box and starter housing for ground wire termination. Make ground wire connections to ground bus in motor control center.

4.13.3.6. **Receptacles**. Receptacles must have a ground wire from green ground terminal to the outlet box ground screw, regardless of type, except for isolated ground devices.

4.13.3.7. **Lighting Fixtures**. Fixtures must have a green ground wire included with the power wires.

4.13.3.8. **Electrical Appliances, Pipe, and Equipment**. Provide fixed electrical appliances and equipment with a ground lug installed for termination of the green ground conductor. Bond the water main with #6AWG conductors.

4.13.3.9. **Ground Resistance**. The grounding system must be provided and tested in the presence of Department to ensure that the ground resistance does not exceed 5 ohms. One week notice must be given before the scheduled test and the Engineer must also have the option to witness the testing. Service at power company interface points must comply with the power company ground resistance requirements. Necessary modifications to the ground electrodes including driving of additional electrodes for compliance must be without additional cost.

4.13.3.10. **Ground Rod Installation**. Drive each rod vertically for not less than 10 ft. and bury minimum of 30 in. below finished grade. The ground rods must be located at least 10 feet apart from each other. Submit a proposed location of the ground rods as part of the conduit layout plan for approval. Where required to obtain the specified ground resistance, install multiple rods, but in no case less than three rods. For ground rods, make the connections by the exothermic process to form solid metal joints.

4.14. **Low Voltage Transformers**. This Section includes dry-type transformers rated 600V and less.

4.14.1. **Submittals**. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices, features, and performance for each type and size of transformer indicated.

4.14.2. **Quality Assurance**. Testing Agency Qualifications: An independent agency, with the experience and experience and capability to conduct the testing indicated, that is a full member company of NETA and that is acceptable to authorities with jurisdiction.

Source Limitation: Obtain each transformer type through one source from a single manufacturer.

Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing a testing agency acceptable to authorities with jurisdiction and marked for intended use.

Comply with IEEE C57.12.91, “Test Code for Dry-Type Distribution and Power Transformers.”

4.14.3. **Products**.

4.14.3.1. **Available manufacturers**. Subject to compliance with requirements, offering products that may be incorporated into the work include, but are not limited to, the following.

- Square D; Schneider Electric;
- Eaton; and
- G. E. Company.

4.14.3.2. **General Transformer Requirements**.

- **Description**: Factory-assembled and tested, air cooled units for 60-Hz service.

- **Cores**: Grain: oriented, non-aging silicon steel.
- **Coils**: Continuous windings without splices except for taps.
  - Internal Coil Connections: Brazed or Pressure type
  - Coil Material: Copper

4.14.3.3. **Distribution Transformers**.

- Comply with NEMA ST 20 and list and label as complying with UL 1561.
- **Cores**: One leg per phase.
- **Enclosure**: NEMA 250, Type 2 unless noted otherwise.
- Core and coil must be encapsulated within resin compound, sealing out moisture and air.
- Tap for transformers 7.5kVA to 24 kVA: one 5% tap above and one 5% tap below normal full capacity.
- Taps for transformers 25kVA and larger: Two 2.5% taps above and two 2.5% taps below normal full load capacity.
- Insulation class: 220°C, UL component recognized insulation system with a maximum of 115°C rise above 40°C ambient temperature. The 115°C rise transformers must be capable of carrying a 15% continuous overload without exceeding a 150°C temperature rise.
- Transformers 15 kVA and larger: comply with NEMA TP 1, Class 1 efficiency levels and tested according to NEMA TP 2.
- Electrostatic shielding: Each winding must have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

4.14.4. **Execution**.

4.14.4.1. **Examination**. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers are installed. Verify that ground connections are in place and requirements of Division 16 Section "Grounding" have been met. Maximum ground resistance must be 5 ohms at location of transformer. Proceed with installation only after unsatisfactory conditions have been corrected.

4.14.4.2. **Connections**. Ground equipment according to "Grounding" Section.

4.14.4.3. **Field Quality Control**. Engage a qualified testing agency to perform tests and inspections and prepare test reports. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters. Remove and replace units that do not pass tests or inspections and retest as specified above.

Infrared Scanning: 2 mo. after Substantial Completion, perform infrared scan of transformer connections. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

4.14.4.4. **Adjusting**. Record transformer secondary voltage at each unit for at least 48 hr. of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10% and not being lower than nameplate voltage minus 3% at maximum load conditions. Submit recording and tap settings as test results.

Output Settings Report: Prepare a written report recording output voltages and tap settings.

4.14.4.5. **Cleaning**. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

4.15. **Lighting**. Provide lighting including furnishing, storing, installing, and connecting fixtures, complete for continuous satisfactory operation. Included is furnishing lamps, mounting brackets, stems, escutcheons, frames, and trim required to match surrounding surface.

4.15.1. **Submittals**. Contractor must verify ceiling types and coordinate trip and mounting hardware before submission of fixtures and must have final responsibility to ensure proper compatibility of fixture type with ceiling system.

Manufacturer's model and catalog numbers change frequently and may not necessarily include features or options as specified herein or required for complete installation. In particular, catalog number may only indicate type and series of required fixture. When specified types, finishes, features, options, and accessories conflict with a given model number, former must govern.

Submit cut sheets for fixtures furnished. Submittals will not be checked for proper or complete catalog numbers.

Under base bid, furnish fixtures and equipment specified or named equals. Where no named equal is given and only "Or approved equal" is noted, Contractor may at his option use alternates of his selection. However, such alternate must conform to the specified fixture's construction, performance, and catalog features and must have a similar aesthetic appearance. Failure to conform will result in rejection of item.

4.15.2. **Products**. Provide products meeting the following requirements.

- Color temperature: 4000K
- Rated Lamp Life: 50,000 hours minimum
- Light fixtures must bear label of Underwriters' Laboratories, Inc. and must be suitable for intended location. Fixtures must be labeled indicating suitability for damp or wet locations where required.
- Each fixture must be supplied with necessary straps, supports, or hangers, or other miscellaneous materials and devices to install them in a satisfactory manner to conform to architectural treatment and finishes in area in which they are installed.

Fixtures furnished must be standard manufacturer's cataloged and stocked fixtures. Specially fabricated fixtures, unless so specified, will not be accepted. Replacement parts and lenses must be readily available from manufacturer. Fixture voltages must be as shown to be connected on drawings. Lighting fixture schedule: (Refer to plans).

4.15.3. **Execution**.

4.15.3.1. **Installation**. Support fixtures from structure above, provide rigid hangers or framing to support units.

Coordinate fixture locations with ceiling framing and equipment locations. Align continuous row fixtures in uniform rows. Furnish metal channels to achieve alignment, if required. Securely support fixtures with approved hangers. Such hangers must be set in perfect alignment and elevation.

Outlet mounted fixtures must be mounted directly to mounting ears of outlet box or to fixture studs as required by selected fixtures. Furnish structural supports for heavy fixtures.

Carefully place splices in outlet boxes or wiring gutters with no crowding in a neat and orderly manner.

4.15.3.2. **Guarantee**. Unless otherwise specified, unconditionally guarantee for period as set forth in this Specification, material, equipment, workmanship, and installation. During this period, adjust, repair, or replace at no cost to the Department, any item or equipment or workmanship found to be defective.

LED fixtures must be guaranteed for at least 5 yr. after Substantial Completion.

4.16. **Automatic Transfer Switch**. Provide solid state logic automatic transfer switch by Schneider Electric, Eaton, or Russel Electric. Mount the switch as part of the MCC as shown on the plans and must be delayed transition type with center-off position between the two available sources.

4.16.1. **Submittals**. Submittal must include Specification sheets showing standard and optional accessories to be supplied; schematic wiring diagrams; dimension drawings; and interconnection diagrams identifying by terminal number each required interconnection between the generator set, pump control panel, and transfer switch.

4.16.2. **Switch Operation**. Provide a four-pole switch with switched neutral.

Provide an automatic transfer switch three-phase control panel that uses solid-state sensing for automatic, positive operation. Provide the following:

- The normal or preferred source voltage across live lines must be monitored line-to-line. Close differential voltage sensing must be provided. The pickup voltage must be adjustable from 75% to 100% of nominal. The dropout voltage must be adjustable from 70% to 98% of the pickup value. The transfer to emergency/secondary will be initiated upon reduction of normal/preferred source to 85% of nominal voltage and retransfer to normal/preferred must occur when source restores to 95% of nominal.
- A test switch to momentarily simulate normal/preferred source failure.
- Harnessing between transfer switch and control panel must have built-in disconnect for routine maintenance.

The moveable parts of the operating mechanism must remain in positive mechanical contact with the main contacts during the transfer operation without the use of separate mechanical interlocks. Automatic operation of the switch must not require power from any source other than the line-to-line voltage of the source to which the switch is transferring.

4.16.3. **Products**.

4.16.3.1. **Equipment**. The automatic transfer switch must consist of a power transfer module and a control module, interconnected to provide complete automatic operation. The automatic transfer switch must be mechanically held and electrically operated by a single solenoid mechanism energized from the source to which the lead is to be transferred. The switch must be rated for continuous duty and be inherently double throw. The automatic transfer switch must be suitable for use with emergency sources, such as engine or turbine generator source, or with another utility source.

Main contacts must be of silver composition. The operating transfer time in either direction must not exceed 1/6th of a second.

Contacts, coils, springs, and control elements must be conveniently removable from the front of the transfer switch without major disassembly or disconnection of power conductors.

Supply a control module with a protective cover and mount separately from the transfer switch for ease of maintenance. Sensing and control logic must be solid state and mounted on plug-in printed circuit boards. Printed circuit boards must be keyed to prevent incorrect installation. Interfacing relays must be industrial control grade, plug in type with dust covers and locking clips.

Automatic transfer switches utilizing components of molded case circuit breakers, contactors, or parts thereof which have not been intended for continuous duty or repetitive load transfer switching are not acceptable.

The automatic transfer switch must be in accordance with the requirements of NEMA standard ICS 2-447 and UL-1008. Automatic transfer switch must be UL listed for use in emergency systems in accordance with Articles 517 and 700 of the National Electrical Code and rated in Amperes for total system transfer including control of motors, electric heating, and LED fixtures.

The automatic transfer switch must be rated to withstand the manufacturer's standard rating for symmetrical amperes short circuit current based on the coordinated circuit breaker.

The automatic transfer switch must be mounted as part of the motor control center as indicated on the plans.

The automatic transfer switch must be delayed transition.

4.16.3.2. **Accessories**.

- Switches must include a time delay on transfer from normal/preferred to emergency/secondary, field adjustable from 6 to 60 sec.
- Switches must be a time delayed transition type with a center position available between the two available source positions.
- Switches must include a time delay on retransfer from emergency/secondary to normal/preferred, field adjustable from 1 to 30 min. The time delay must be automatically bypassed if the emergency/secondary source fails and the normal/preferred source is available.
- The switches must include voltage and frequency sensing of the emergency/secondary source and must be factory set to allow transfer to emergency/secondary when that source is at approximate rated voltage and frequency.
- Contacts rated 10 Amps, 32 Volts DC which close when the normal source fails must be provided to initiate engine starting, where applicable. Provide signals between automatic transfer switch, generator, and pump control panel as shown on the plans.
- Switches must include a time delay to ignore momentary outages. It must delay closing of the engine start contacts for an adjustable time from 0.5 to 6 sec.
- Switches must include a time delay for engine cool down, adjustable from 0 to 15 min.
- One auxiliary contact closed when the switch is in the normal/preferred position and one closed when the switch is in the emergency/secondary position must be provided. Contacts must be rated 10 amps, 480 volts AC. Provide signals to the pump control panel as shown on the plans.
- Two pilot lights to indicate switch in normal/preferred or emergency/secondary position must be installed in the door of the enclosure.
- Two contacts must be provided which close when the generator runs and opens when the generator stops. They must be rated 10 amps, 120 volts. Provide signals to the pump control panel as shown on the plans.
- A plant exerciser that is (7-day, time adjustable more than 30 min.) field adjustable for exercising the generator on 30-min. increments must be provided. Provide a selector switch for load/lo load operation.
- Outputs must be provided to the generator for control and to the pump control panel form monitoring and alarm as indicated on the plans.
- Switches must be provided with auxiliary contacts to indicate normal utility power failure.

4.16.4. **Execution**.

4.16.4.1. **Testing**. Perform the following tests.

- Certified laboratory test data on a switch of the same design and rating must be provided to confirm the following switch abilities:

- Overload and endurance per Tables 21.2 and 23.2 of UL-1008 when enclosed according to Paragraph 1.6.
- Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits of the insulation in contact with current carrying parts.
- Withstand current tests per Paragraph 25 of UL-1008 for 5000A rms symmetrical, at 480V and X/R ratio of 6.6.
- No welding of contacts Transfer switch must be operable to alternate source after they withstand current tests.
- Test remote monitoring and alarm signals to and from sources and the pump control panel.

Production units should be subjected to the following factory tests:

The complete automatic transfer switch must be tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency, and time delay settings are in compliance with the Specification requirements.

The complete automatic transfer switch must be subjected to a dielectric strength test per NEMA Standard ICS 1-109.05.

The control panel must meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 and the impulse withstand voltage test in accordance with the proposed NEMA Standard ICS 1-109.

An authorized representative of the switch manufacturer and Engineer must attend start-up activities to assist the Contractor with installation, testing, and certifying the system.

4.16.4.2. **Certification**. The manufacturer must provide a letter certifying compliance with the requirements of the transfer switch specifications. The certification must identify equipment by serial number and must include no exceptions to the Specifications, except those stipulated with the submittal.

4.16.4.3. **Guarantee**. Each transfer switch must be provided with an operator's manual providing installation and operating instructions.

4.17. **Standby Generator**. Provide a standby power generator system in conformance with the plans and Specifications. Perform work in accordance with NFPA, NEMA, and IEEE standards.

4.17.1. **Quality Assurance**. The standby generator system, including Engineer-generator set, generator, and generator controls, must be furnished by a single manufacturer who has been regularly engaged in the production of engine generator sets, generators, engine auxiliaries, and controls for at least 10 yr. The manufacturer must have a local representative who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.

The generator set and controls must provide a completely automatic unattended operation for the duration of a loss of normal utility power. Controls must be the standard of the manufacturer.

The generator set manufacturer must assume full responsibility for correct operation of the entire standby power generator system, including the fuel distribution system.

Final Production Tests:

- Each generator set must be tested under varying loads with guards and exhaust system in place before shipment of the standby power generator system.

- Final production tests must include single-step load pickup, transient and steady state governing, safety shutdown device testing, voltage regulation, rated power, maximum power.
- The specified generators are to be used to start and run large motors.

The standby power generator system must be guaranteed in writing for defects in materials and workmanship for a period of 5 yr. from the date of Substantial Completion. Multiple warranties for individual components such as engine, alternator, and controls, will not be acceptable. The warranty must be comprehensive, and must include parts, labor, travel, and other miscellaneous expenses.

In addition to the stipulated guarantee, the generator manufacturer or his approved agent, must provide a comprehensive service Contract for a period of 5 yr. from the date of Substantial Completion. The service Contract must cover necessary parts, labor, travel, and other services required to keep the generator in complete working order at all times. The only items excluded from the service Contract must be fuel and regular oil changes and lubrication.

4.17.2. **Submittals**. Provide the following submittals.

- Shop drawings showing fabrication, assembly, foundation, and installation;
- Catalog data and detailed Specification sheets for standard and optional accessories to be supplied;
- Wiring diagrams and electrical schematics indicating operation, controls, and power supply;
- Operation and maintenance manual for standby power generator system; and
- Certified copies of manufacturer's final production test results.

4.17.3. **Materials**. Equipment specified for the standby power generator system must be manufactured by Caterpillar, Cummins, or approved equal. Generator must have a rating as indicated herein or on the plans. Basis of design for generator is Caterpillar. Any changes required due to equal manufacturer being submitted will be paid for at the expense of the Contractor with no extra cost to the owner.

4.17.3.1. **Engine-Generator Set**. Mount the engine-generator set on a structural steel base to maintain proper alignment between components. The structural steel base must incorporate vibration isolators of the type and quantity recommended by the manufacturer to obtain at least 95% vibration attenuation.

Engine must be liquid cooled for use with natural gas.

The engine must be furnished with the following accessories.

- Replaceable full-flow oil filters and oil drain valve with hose extension. Provide 2 spare of each filter.
- Replaceable dry element air cleaner. Provide 2 spare of each filter.
- Replaceable fuel filters. Provide 2 spare of each filter.
- Provide 2 spare of each type of belt.
- Electric starting systems, including starting motor, batteries, battery charger, cables, and battery rack. Provide float/equalize battery charger. Batteries must be provided with cold cranking amp capacity 25-percent higher than the manufacturer's standard for the unit provided.
- Batteries must be lead-acid or nickel cadmium type and battery charger must include temperature compensation feature with voltmeter and ammeter to indicate battery charging voltage and current.
- Safety devices to protect the engine against high and low coolant temperature, low lubricating oil pressure, overspeeding, and overcranking.
- Engine-mounted, thermostatically controlled jacket water heater rated as required. The heater must be disconnected by an oil pressure switch mounted on the engine when the engine starts.
- Unit mounted radiator with engine driven fan.
- Instrument panel with lubricating oil pressure gauge, water temperature gauge, and battery charging ammeter.

- Hospital type (critical) exhaust silencer, sized as directed by the generator set manufacturer. Provide thermal insulation jacket. Wrap silencers and the straight pipe section from the silencer to the wall thimble with high temperature-flexible insulation which conforms to Military Specification MIL-I-16411-E, Type II. Insulation must be Type E Fiberglass Insulation designed for use in insulating high temperature equipment as manufactured by Advanced Thermal Products, Inc. or equal. Insulation must be flexible, lightweight and must not compact under vibration. Insulation must be manufactured from chopped glass fibers and must be free from resinous binders. Insulation must be installed in conformance with the manufacturer's recommendations.
- Necessary piping, stainless steel flexible exhaust tubing, fittings, mounting hardware, flapper type exhaust cap, and other equipment necessary to complete the exhaust system must be provided. Exhaust pipe opening through generator enclosure or building must be made weatherproof, and vermin-proof. Provide manufacturer approved wall thimble.
- The generator set supplier must furnish lubricating oil to fill the crankcase and 50% ethylene glycol antifreeze solution to fill the engine cooling system.
- Unit mounted main circuit breaker.

4.17.3.2. **Generator**. Provide an alternator that is salient-pole, brushless, 12-lead reconnectable, of 2/3 pitch to eliminate the third harmonic, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed for smooth voltage waveform. The insulation must meet the NEMA standard (MGI-22.40 and 16.40) for Class H and be vacuum, impregnated with epoxy varnish to be fungus resistant per MIL 1-24092. Temperature rise of rotor and stator must be limited to NEMA Class F. The excitation system must be brushless construction controlled by a solid-state voltage regulator located in the switchgear.

Frequency regulation must be isochronous from no load to rated load. The voltage regulator must be solid-state design and must provide no load to full load regulation within plus or minus 1% of rated voltage during steady-state conditions.

Performance criteria must be equal to the specified equipment. A rheostat must provide a minimum range of plus or minus 10% voltage adjustment from rated value.

The alternator, exciter, and voltage regulator must be designed and manufactured by the generator set manufacturer so that the characteristics are matched to the torque curve of the prime mover. The system must provide automatic voltage reduction if the load demand exceeds the engine capacity to prevent engine stalling and saturation of magnetic components. Systems that routinely select a linear-type (straight line) constant volts/hertz characteristic without regard for the engine power and torque characteristics are unacceptable.

Upon one-step application of any load up to 100% of the rated load at 0.8 power factor, the voltage dip must not exceed 20% and must recover to plus or minus 2% of rated voltage within one second.

A resettable line current sensing circuit breaker with inverse time versus current response must be furnished. This breaker must not trip within the 10 sec. specified above to allow selective tripping of downstream fuses or circuit breakers under a fault condition. This breaker must not automatically reset preventing restoration of voltage if maintenance is being performed. Generator breaker must selectively coordinate with downstream overcurrent protection devices. Breaker must be provided with adjustable long time, short time, and instantaneous settings as required to achieve coordination.

The generator, with a single maintenance-free bearing, must be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

4.17.3.3. **Control System**. The standby power generator system must be provided with a generator-mounted solid-state microprocessor control and starting panel, incorporating complete controls for functions of the generator set and associated mechanisms. The panel must be of the dead front type, NEMA 1 construction

and must be mounted and wired to the generator set by the engine generator set manufacturer. Control wiring must have termination identification on each wire.

Engine-generator controls must include the following:

- Two-wire, 24-volt DC engine controls including oil pressure gauge, coolant temperature gauge, and charge rate ammeter.
- A manual selector switch providing three control positions, RUN-STOP-REMOTE, must be included on the console. The RUN position must permit the engine to be started locally at the sot and run unloaded; the STOP position must serve as the RESET for alarm shutdown conditions; and the REMOTE position must allow automatic starting on a signal from the pump control panel.
- Control console containing complete controls, which start the engine on closing contact, and stop the engine on opening contact. The starting controls must be operated either manually or from a contact provided on the automatic transfer switch. When the engine fires, the starting controls must be disconnected automatically. If the engine fails to fire or any safety device should operate while the engine is running, the engine must stop immediately, and the starting controls locked out until manually reset.
- Generator controller must provide overload and short circuit protection required for the generator.
- Solid-state voltage regulator.
- Manual reset field circuit breaker.
- Control Panel mounted Emergency E-Stop: Flush; wall mounted, unless otherwise indicated; and labeled. Push button must be protected from accidental operation.
- AC output controls including voltmeter, ammeter, frequency meter, running time meter, voltage adjusting rheostat, and speed potentiometer.

The required inputs and outputs to and from the generator, automatic transfer switch and pump control panel for control, monitoring and alarm as shown on the plans. These must include, as a minimum,

- Utility service failure alarm,
- Generator start control,
- Generator running status,
- Generator failure alarm,
- Station on generator power status,
- Generator not in auto status,
- Low oil alarm,
- High temperature alarm, and
- Low gas pressure alarm.

Alarm signals to the Pump Control Panel must be wired to terminal blocks inside the generator enclosure for customer connection.

4.17.3.4. **Outdoor Weather-Protective Sound Attenuating Enclosure**. The generator must be provided with a sound-attenuating enclosure which must allow the generator set to operate at full rated load in the ambient conditions. The enclosure must reduce the sound level of the generator set while operating at full rated load to a maximum of 75dBA at any location 23 ft. from the generator set in a free field environment. Housing configuration and materials used may be of any suitable design which meets application needs, except that acoustical materials used must be oil and water resistant. No foam materials must be used unless they can be demonstrated to have the same durability and life as fiberglass.

The enclosure must include hinged doors for access to both sides of the engine and alternator, and the control equipment. Key-locking and pad-lockable door and latches must be provided for doors. Door hinges must be stainless steel.

The enclosure must be provided with an exhaust silencer which is mounted inside of the enclosure and allows the generator set package to meet specified sound level requirements. Silencer and exhaust must include a rain cap and rain shield.

Sheet metal must be primed for corrosion protection and finish painted with the manufacturer's standard color. Prime and paint surfaces of metal parts.

Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts must not be acceptable. Fasteners used must be corrosion resistant and designed to minimize marring of the painted surface when removed for normal installation or service work.

Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110% of rated load for 2 hr. with ambient temperature at top of range specified in system service conditions.

Louvers: Fixed-engine, cooling-air inlet, and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

Automatic Dampers: At engine cooling-air inlet and discharge. Dampers must be closed to reduce enclosure heat loss in cold weather when unit is not operating.

Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

4.17.4. **Execution**.

4.17.4.1. **Installation**. Mount the generator and securely anchor to the concrete pad. Install the standby power generator system as indicated on the plans and in conformance with the Manufacturer's recommendations.

The generator concrete pad must be as shown on the plans with a minimum 6-in. clearance all around. Where access platforms and stairs are necessary, the Contractor must provide properly sized concrete pad as well as turn downs for the platforms and stairs.

4.17.4.2. **Field Quality Control**. Verify that fuel piping, electrical connection, and exhaust piping work is complete. Demonstrate operation with selector switch in hand-off-automatic positions. Demonstrate performance of engine water jacket heater by filling the engine cooling system with coolant at room temperature. Energize the water jacket heater, determine the load current to the heaters and verify that water is rising in temperature using hand sensation as a detector.

Automatic Transfer Switch. Verify that the transfer switch transfers to engine-generator source when normal supply voltage is less than 90% of rated voltage and retransfers when normal supply is 100% of rated voltage. Use suitable test instruments to verify voltages. Verify that failure of engine generator power source causes transfer to normal power supply by operating generator load circuit breaker. Check sensor operation to prevent transfer to emergency power until the generator output reaches 100% of voltage and frequency. Use suitable test instruments to verify voltages.

Control Panel: Electrically check automatic engine shutdown controls as the engine proceeds through its start-up sequence as follows:

- **Engine Overcrank**: Disconnect one wire from the fuel supply solenoid valve and turn the manual selector switch to the run position causing the engine to attempt to start for the period and number of cycles defined for overcrank alarm contacts to close. Verify overcrank alarm actuation and lockout. Reconnect the wire to the fuel supply solenoid valve and start the engine by turning the manual selector switch to the run position.
- **Low Oil Pressure**: Electrically short out the low oil pressure switch contacts to verify engine shutdown.

- **High Coolant Water Temperature**: Electrically short out the high coolant water temperature thermostat contacts to verify engine shutdown.
- **High Lubrication Oil Temperature**: Electrically short out the high coolant water temperature thermostat contacts to verify engine shutdown.
- **Engine Overspeed**: Manually adjust speed into overspeed range to verify engine shutdown.

Generator Remote Alarms: Provide the following alarm signals to the Pump Control Panel.

- Generator Overcrank,
- Generator Running,
- Generator Fail,
- Generator Not In Auto,
- Loss of Gas Pressure,
- Low Oil, and
- High Oil Temperature.

Engine Generator Operation:

- With normal electrical power supply to transfer switch, open main circuit breaker to verify that initiating Contractor closes to start automatic sequence. Engine should start and control panel instruments should show voltage and frequency reach approximately rated value.
- Close normal power main circuit breaker. Verify that the automatic transfer switch transfers load back to normal power, initiating contactor opens, beginning the automatic stop sequence. Verify that the generator set stops automatically if the engine has a failure.
- Start and stop engine generator at least six times within a 2-hr. time period to verify operation.
- Demonstrate that safety devices furnished for automatic engine shutdown will cause engine shutdown when actuated.

Conduct a 4-hr. load bank test on the generator and submit a field report indicating the test results.

Coordinate, connect and test required inputs and outputs between the generator system, automatic transfer switch and pump control system.

An authorized representative of the manufacturer must attend start-up activities to assist the Contractor with installation, testing and certifying the system.

4.18. **Motor Control Center**. Furnish and install a complete motor control center including required number of vertical sections, main breaker, digital meter, surge protective device, combination type motor starters, circuit breakers, magnetic relays, selector switches, push buttons, pilot lights, control transformers and special controls as shown on the plans and specified herein. An automatic transfer switch, panelboard, and transformer must also be included in the MCC.

The motor control center must be new and limited to products regularly produced and recommended for service ratings in conformance with engineering data or other comprehensive literature. In cases where device, or devices, or part of equipment is herein referred to in singular, reference must apply to as many items as required to complete installation.

4.18.1. **Special Requirements**. The Motor Control Center must be furnished, programmed, commissioned, and tested by the Pump Control System Supplier. The electrical contractor must install the Motor Control Center and provide conduit and wiring.

The plans indicate certain motor starters to be energized by a programmable controller output. If the current rating of the output is not enough to energize the starter directly, provide an interposing relay in the motor starter compartment and wire the relay as required to energize the starter.

Install Motor Control Center on concrete base. Coordinate size and location of concrete base.

The dimensions on the plans for the Motor Control Center are the maximum allowable dimensions for the Motor Control Center. Provided dimensions allow for installation of the basis of design electrical components as detailed below and elsewhere on the plans and Specifications. The Contractor must be responsible for any changes in the work made necessary from the installation of equipment other than the basis of design. Make changes without any additional cost to the Department or delay to project completion.

4.18.2. **Regulations**. Comply with the Regulations, Standards, and Publications below.

- UL Underwriters' Laboratories, Inc.,
- NEC,
- NEMA, and
- ANSI.

4.18.3. **Submittals**. Shop drawings must be complete and must indicate dimensions, installation methods, size, weight, capacity, ratings, integral controls and types of materials, elevations, and sections. Shop drawings must include manufacturer's literature and complete information on the following.

- Freestanding Vertical Sections,
- Main Circuit Breakers,
- Digital Meters,
- Surge Protective Devices,
- Automatic Transfer Switch,
- Thermal magnetic Type Circuit Breakers,
- Magnetic Across-the-Line Motor Starters,
- Control Transformers,
- Relays,
- Selector Switches,
- Push Buttons,
- Pilot Lights,
- Elapsed Time Meters,
- Special Controls,
- Engineered Control Diagrams and Connection Diagrams,
- Nameplate Schedule, and
- Variable Frequency Drives and Solid-State Starters.

Manufacturer. The Motor Control Center basis of design is Square D Model 6. Equivalent equipment as manufactured by Eaton Corporation is acceptable subject to approval and compliance with specific requirements listed herein. Contractor is responsible for any additional work required due to the selection of equipment other than the basis of design at no extra cost to the owner.

4.18.4. **Products**.

4.18.4.1. **Motor Control Center Structure and Configuration**. Provide a Motor Control Center must be NEMA Type I, gasketed. Wiring must be NEMA Class II, Type C. The motor control center must have a main breaker as indicated on the plans to feed the horizontal bus. Provide lugs of adequate size to terminate incoming cables. The motor control center must be furnished with a ground bus.

Motor starter units must be combination type with a molded case circuit breaker. Control voltage for units must be 120 volts. The Motor Control Center must be rated 480V, 3 phase, 3 wire, 60Hz and must be braced to withstand a short circuit current of 65,000 rms symmetrical amps. The motor control center must consist of vertical sections bolted together to form a rigid, freestanding assembly.

Vertical sections must be formed of 13-gauge hot rolled steel with uniform blemish-free surfaces. Top and bottom structural parts must be 10-gauge. End closing plates must be 12-gauge, and unit parts and doors must be 14-gauge. Base channels must be provided constructed of rugged steel to easily withstand the stress of transit and moving the control center into position. Provide bolt holes in the base channels in sections for the purpose of bolting the control center to the floor. Provide steel removable lifting angles on the top of the sections for convenience in handling the control center.

Each section, to comply with standards of NEMA, must be approximately 90 in. high excluding lifting angles and base channels. It must be approximately 20 in. deep and width must be as required for the application or as indicated on the plans.

End sections must have end-closing plates, which can be removed for the addition of future sections. The top plate must be of a removable one-piece construction for added convenience in cutting conduit holes. Cover unused unit spaces with removable blank plates flanged on all sides and with captive screws.

4.18.4.2. **Main Circuit Breaker**. Where shown, main circuit breakers must be provided, individually mounted, and identified. The main breakers must have enough interrupting capacity to properly close against and interrupt instantaneously, without damage, the maximum short circuit current available to the breaker. Minimum interrupting capacity must be 65,000 amperes symmetrical at 480V. The main breaker must be 100% rated. The main circuit breakers must be furnished with GFI protection. Auxiliary contacts must be provided for the main circuit breakers and the automatic transfer switch to remotely signal breaker position and switch status to the pump control system PLC.

4.18.4.3. **Digital Meter**. Provide a digital meter in the Motor Control Center to provide complete electrical metering for the active service. The digital meter must be microprocessor based and must be furnished complete with current transformers. The digital meter must be Square D PM5000, Eaton, or approved equal. Furnish a digital meter with an alarm contact for remote indication of a power failure on any individual or all three phases. Provide optional communication interface and power management software and connect via network communications to Pump Control System.

In addition to the digital meter, install a three-phase monitor to sense the presence of utility power on the line side of the utility main circuit breaker. The monitor must output a discrete signal which must be hardwired to the PLCs in the Pump Control Panel for monitoring. The three-phase monitor must be ATC Diversified Electronics SLA (230/440) ALE, Eaton, or approved equal, with voltage rating as required.

4.18.4.4. **Internal Surge Protection**. Where shown as internally mounted, furnish a surge suppressor in the Motor Control Center for each normal and emergency service feeder. The surge suppressor must be UL 1449 Second Edition Listed (1998). Unit must protect all modes (L-L, L-N, L-G, N-G) applicable. Unit must have 240kA of surge capacity per phase with a let-thru voltage of less than 1500V L-L and 700V L-G. A disconnecting means must be provided ahead of the surge suppressor so the unit can be serviced without de-energizing the service.

Unit must be furnished with dry contact alarm outputs to indicate any module failure. Surge suppressor must have AC tracking filter with EMI/RFI filtering. Each module must be fused individually, thermally protected, and have LED indication.

Unit must be provided and installed by MCC manufacturer.

4.18.4.5. **Horizontal Wireways**: Adequate conduit entrance space and wire entry room must be provided at both the top and bottom of each section. The bottom horizontal wireway must be 12 in. and the top horizontal wireway must be 6 in. and both must extend through the length and depth of the control center section with openings between sections. Covers over these wireways must be equipped with captive type screws to prevent loss of hardware during installation. These wireways must be isolated from the bus bars.

4.18.4.6. **Vertical Wireways**. Install a vertical wire trough located on the right-hand side of each standard section and with a cross-sectional area of not less than 28 sq.in. It must extend from the top horizontal wire trough to the

bottom horizontal wire trough for the purpose of routing user's motor and control wires to the control units. The wire trough must be isolated from the bus bars to guard against accidental contact. A separately hinged door with captive type screws must cover the vertical wire trough for safe and easy access to wiring without disturbing control units. Wire ties must be furnished in the vertical wire trough to group and securely hold wires in place for a neat, orderly installation.

Where wire access ports between unit spaces and vertical wire trough are open, shutters must be provided to prevent items, such as a fish tape, from accidentally entering the unit space. Snap-in wire grommets must be provided in wire access ports for Size 2 units and smaller for isolation and added protection of small wires. For larger units) snap-in wire guards must be provided for added protection of larger wires.

4.18.4.7. **Vertical Sections**. Divide each vertical section into compartments, each containing a combination starter, circuit breaker, or other cSontrol assembly as indicated on the plans. Provide power to these compartments from the main bus by bus bars extending the full height of the unit. Sections must also be provided with horizontal spaces at the top and at the bottom, which must line up with adjacent section to form horizontal wiring raceways along the entire length of the control center.

4.18.4.8. **Compartments**. Compartments must be built in interchangeable combinations of modular heights. A full vertical section must contain six equal NEMA Size I modular compartments exclusive of top and bottom wiring spaces. Starter compartments must not be less than 12 in. high. Only 1/2 and integral multiples of the basic module will be allowed. Compartments for NEMA size 4 and smaller starters must be draw-out type.

Provide guide rails in the structure for supporting and aligning a unit during its removal or replacement. Draw out units must have pressure type, line disconnecting stabs of high strength alloy and must be held in place by means of quick acting, captive machine screw fasteners arranged so the units can be removed or remounted readily without access to the rear of the structure. Each compartment whether draw out or stationary, must be enclosed and effectively baffled to isolate any fault which may occur and must be covered by an individual door fixed to the structure with a continuous full length piano hinge or two (three for doors over 36 in. high) semi-concealed, heavy-duty, pin type hinges. Doors must be secured with captive, quick acting machine screw fasteners and must be arranged to completely cover live parts whether the draw out unit is present or not.

Doors two space factors (24 in. high) and larger must be provided with stainless-steel handles and stainless-steel hardware, for ease of opening.

4.18.4.9. **Bus Bars**. Furnish main horizontal bus bars rated as indicated on the plans but not less than 1000 amperes must be provided at the top or center of the control center and extend its entire length, except when cut and supplied with splice bars to divide the control center for ease in handling or when section is indicated on the plans to be furnished without bus.

Horizontal bus bars of copper must be mounted edge-to-edge to provide greater mechanical strength. Vertical copper bus bars must be rated not less than 600 amperes for adequate current carrying capacity in a variety of plug-in applications. Horizontal and vertical bus bars must be electrolytically tin-plated copper. Connections between horizontal and vertical busses must be joined by bolts, conical spring washers for constant pressure joints and self-clinching nuts to allow joint maintenance from the front.

High strength glass reinforced alkyd insulators must be used as bus supports and as unit plug-in insulators. Bus and plug-in insulators must be red to indicate the proximity of energized bus parts.

The temperature rise, above ambient temperature outside the enclosure, of bus bars and connections must not exceed 50°C and that of connections to insulated cable must not exceed 45°C when operated continuously at rated current. Buswork, wiring and equipment must be rated to withstand short circuits of 65000 rms symmetrical amperes at 480 volts or as noted on the plans.

Provide a copper ground lug in each incoming line vertical section capable of accepting a #8 to 250 MCM cable, A horizontal and vertical copper ground bus must be provided in each section of the motor control

center. Horizontal ground bus must run continuously throughout the control center except where splits are necessary for ease of shipment and handling; in which case, splice bars must be provided. Ground bus must be tin plated copper and have a cross-sectional area of equal to 28% of the main horizontal bus cross-sectional area. Horizontal ground bus must be located at the bottom of the motor control center.

Where required, a full rated tin-plated copper neutral bus must be provided.

4.18.4.10. **Bus Barrier**. Insulated horizontal and vertical bus barriers must be furnished to reduce the hazard of accidental contact, these barriers must have a red color to indicate proximity to energized busses. Vertical bus barriers must have interlocking front and back pieces to give added protection on all sides and must segregate the phases from each other. Small, separate openings in the vertical bus barriers must permit unit plug-in contacts to pass through and engage the vertical bus bars.

Bottom bus covers must be provided below the vertical bus to protect the ends of this bus from contact with fish tapes or other items entering the bottom of the enclosure. Unused plug-in openings must have plastic snap-in closing plates.

4.18.4.11. **Unit Plug-in**. Unit plug-in contacts must be provided for Size 1 through Size 5 motor starters and for branch circuit breakers.

The plug-in connection must be 2-point connection for each phase designed to tighten during heavy current surge. The plug-in fingers must be tin plated to yield a low resistance connection and must be backed by spring steel clips to provide high-pressure connection points. Contact fingers must be mounted in their support so these fingers become floating and self-aligning to allow solid seating onto the vertical bus bars.

4.18.4.12. **Unit Doors**. Each unit must have a door securely mounted with hinges, which allow the door to swing open a minimum of 112°. Unit doors must be fastened to the stationary structure, so they can be closed to cover the unit space when the units have been temporarily removed, Unit doors must be held closed with captive type screws, which engage self-aligning cage nuts. These screws must provide at least two threads of engagement to help hold unit doors closed under fault conditions, Removable door panels held captive type screws must be provided on starter unit doors for mounting push buttons, selector switches or pilot lights. Blank door panels capable of accepting future push button devices must be furnished when push button devices are not originally specified for starter units. Starter units must have an external low-profile overload reset button.

Pilot devices and instruments, including push buttons, reset buttons, and indicating lights, must be flush mounted in the compartment doors. Equipment must not be mounted on the rear of draw out units. Arrange equipment within the unit to provide ample electrical clearances and easy access for maintenance. Draw out combination starter unit of a given type and size must be made interchangeable. Only those items, which are common to all starters, must be mounted in the unit.

4.18.4.13. **Unit Support Pan**. Each plug-in unit must be supported and guided by a tilt and lift-out removable pan, so unit rearrangement is easily accomplished. For easy unit installation and rearrangement, transfer of this unit support pan from one location to another must be accomplished without the use of tools after the unit and door have been removed.

4.18.4.14. **Unit Saddles**. Each plug-in unit must have a sheet steel saddle designed to physically isolate the unit from the bus compartment and adjacent units. Saddles must be equipped with captive, self-aligning mounting screws, which hold the unit securely in place during shipment and maintain the unit and structure at the same potential. Handholds must be provided on each plug-in unit to facilitate unit removal.

4.18.4.15. **Disconnect Operator**. A flange mounted operator handle must be supplied for each switch or breaker. To prevent false circuit indication, this mechanism must be engaged with the switch or breaker at all times regardless of unit door position. The operator handle must have a conventional up-down motion with the down position as “OFF.” It must be possible to lock this handle in the “OFF” position with up to three 3/8 in.

diameter shackle padlocks. The operator handle must be color coded to display red in the “ON” position and black in the “OFF” position.

The operator handle must be interlocked with the unit door so the disconnect cannot be switched to the “ON” position unless the unit door is closed. It must be possible to defeat this interlock by a deliberate act of an electrician should he desire to observe the operation of the operator handle assembly. This interlock must also prevent opening the unit door unless the disconnect is in the “OFF” position. A defeater for this action must also be provided in the event an electrician must gain access to the unit without interrupting the service.

4.18.4.16. **Starter Units**. Starter units must be completely draw out Type B, sizes as indicated on the plans, so units may be withdrawn without disconnecting any wiring. Units over three space units high may be bolt-in type. A positive guidance system must be provided to assure proper alignment of wedge-shaped power stabs in dead-front openings in vertical power bus. The screw racking mechanism must serve as a mechanical advantage to the operator during unit insertion or removal. Stab-in power terminals must be of a type that will increase contact pressure on short circuits.

Starter units must be rated to withstand short circuits of 65,000 rms symmetrical amperes at 480 volts or as noted on the plans.

Starter units must be furnished with start counters.

Provide individual 3-phase monitors that instantly turns off the starter upon phase interruption or loss. Electrical overloads will not be accepted for this function.

4.18.4.17. **Thermal Magnetic Circuit Breakers**. Thermal magnetic circuit breakers must have quick-make, quick-break mechanisms and must visually indicate whether the breaker is closed, open or tripped.

Breakers must have enough interrupting capacity to properly close against and interrupt instantaneously, without damage, the maximum short circuit current available at the breaker. Minimum interrupting capacity of breakers must be 65,000 amps rms symmetrical at 480 volts. Provide auxiliary contacts on the circuit breakers where indicated on the plans.

Provide adjustable Long Time, Short Time, and Instantaneous trip settings for breakers 250 Amps and larger.

4.18.4.18. **AC Magnetic Starters—Line Voltage Type**. Motor starters must be across-the-line magnetic type, rated in conformance with NEMA standards, sizes, and horsepower ratings. Starter sizes must be as indicated on the plans. Minimum starter size must be NEMA 1.

Across-the-line magnetic starters must be equipped with double-break, silver alloy contacts. Contacts must be replaceable without removing power wiring or removing starter from panel.

Coils must be of molded construction and must operate on 120 volts AC. Coils must be replaceable from the front without removing the starter from the panel.

Overload relays must be electronic. Provide Allen Bradley Bulletin 193 E1, Model EE Square D, or approved equal.

Motor starters must be provided with three phase monitors which must disconnect the corresponding load during single phasing conditions.

Provide individual 3-phase monitors that instantly turns off the starter upon phase interruption or loss. Electrical overloads will not be accepted for this function.

4.18.4.19. **Electrical Interlocks**. Furnish starters with electrical interlocks as shown on the plans plus two spare normally open and 2 spare normally closed contacts. Arrangements must be convertible from normally open to normally closed.

4.18.4.20. **Control Transformers**. Provide a control transformer for each motor starter control circuit as indicated on the plans. Control transformers for individual control circuits must be 480 volts to 120 volts and must be protected according to code. Size must be as required plus 50VA spare capacity. Primary fuses must be Class “CC.”

4.18.4.21. **AC Magnetic Relays**. 600 VAC magnetic relays must have convertible contacts and must be rated for 0 to 600 volts, inductive, 60 amperes make, 6 ampere break, 10 ampere continuous, with at least four poles and provision to add up to four poles making a total of 8.

Contacts must be double-break, silver. Contacts must be convertible from normally open to normally closed or vice versa, without removing the relay from the panel or enclosure. Contacts must be color coded or engraved with respective normally open or closed symbol to indicate status.

Coils must be molded construction, continuous duty rated, and must operate on 120 volts AC.

Terminals must be provided with pressure wire connectors.

4.18.4.22. **Switches**. Selector switches must be non-illuminated. Switches must be 30.5 mm, heavy-duty, oil tight. Switches must have double-break silver contacts. Switches must be maintained contact type unless otherwise indicated on plans. Provide auxiliary contact blocks as indicated on the plans or in the Description of Operation.

Emergency stop pushbuttons must be snap-type, maintained-contact, push to open, pull to close, mushroom style switches. Allen Bradley 800 series, Square D, or approved equal.

4.18.4.23. **Push Buttons**. Push buttons must be non-illuminated. They must be 30.5 mm, heavy-duty, oil tight. Contacts rated for 10 amps minimum. Push buttons must be normally open or normally closed, as required, momentary contact type, unless otherwise noted on the plans.

4.18.4.24. **Pilot Lights**. Pilot lights must be LED, with push to test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12–130V DC/AC power and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Generally, color caps must be green for “run” and red for “stop” or “off.”

4.18.4.25. **Elapsed Time Meters and Timers**. Elapsed time meters must be time totalizer, non-resettable. They must have a synchronous motor, which must drive a set of digit readout wheels to indicate the total time the unit is energized. Readout must be five-digit including 1/10 digit. Range must be 0 to 9999.9 hr. Voltage rating must be 120 volts. Elapsed time meters must be ENM Company Series T50, Square D, or approved equal. Time meters must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the bucket.

Repeat cycle timers must be mounted inside the bucket with their display through the front panel so the display can be read on the outside face of the bucket. Timer must be Allen Bradley Model 700-HXM66SZ24, Square D or approved equal.

4.18.4.26. **Identification**. A control center identification number nameplate describing section catalog numbers and characteristics must be fastened on the vertical wire trough door of every section. Each control center unit must have its own identification number nameplate giving unit catalog number fastened to the unit saddle near the upper left-hand corner. These nameplates must also have suitable references to factory records for efficient communication with supplier. Each control center unit must also have an engraved Bakelite nameplate fastened to the outside of each unit door.

4.18.4.27. **Wiring**. Wire the motor control center in conformance with NEMA class and type previously specified and must be furnished to be interconnected with a programmable controller system.

Bore 120 VAC control wiring. Wiring for 24 VDC PLC inputs must be blue. Label wiring in each MCC cubicle.

Mount quick separating, pull apart terminals on lift-out brackets in the units. Label terminals.

4.18.4.28. **Finish**. Painted parts must undergo a phosphatizing prepainting treatment for rust resistance and good paint bond. Use enamel paint, which must be baked for a durable, hard finish. Paint unit saddles white for easy interior visibility. Paint removeable push button plates, flange mounted operator handles and trim plates, and top horizontal wire trough cover plates a contrasting charcoal gray. Other painted parts must be painted ANSI-49 dark gray.

Plate unpainted parts for resistance to corrosion.

4.18.5. **Execution**.

4.18.5.1. **Field Services**. Perform start-up and testing on the Motor Control Center.

- Test the operation of each motor starter and MCC controls.
- Program the automatic transfer switch and test the operation of the transfer with standby generator.
- The Engineer must have the option to witness start-up and testing.
- Conduits entering the bottom of the MCC must be extended at least 2 in. above surface of equipment pad.

Training. Training must include theory of operation, maintenance and troubleshooting procedures, and programming methods. Conduct start-up, testing activities, and training activities on different days.

4.18.5.2. **Installation**. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.

Install motor-control centers on concrete bases. Coordinate size and location of concrete bases.

4.19. **Variable Frequency Controllers**.

4.19.1. **References**. The Variable Frequency Controller (Drive) must be designed to meet the following Specifications.

- NEC;
- NEMA ICS 3.1: Safety standards for construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems;
- NEMA 250 – Enclosures for Electrical Equipment; and
- UL 508A.

4.19.2. **Qualifications**.

Manufacturer: Only manufacturers with at least 10 yr. experience specializing in the design and manufacturing of PWM Drives must be acceptable manufacturers.

Support: Only manufacturers who have maintained factory trained and authorized service facilities within 100 mi. of the project and have a demonstrated record of service for at least the previous 3 yr. must be acceptable manufacturers. Full-time support personnel must be employed by the manufacturer.

Certification: Only manufacturers certified to ISO-9001 Series of Quality Standards with drive products manufactured in an ISO certified facility to assure quality and corrective action procedures have been adhered to must be acceptable manufacturers.

4.19.3. **Products**.

4.19.3.1. **Manufacturers**. Variable Frequency Controller basis of design must be Square D with 3% line reactor or approved equal by Rockwell Automation or Benshaw. The Contractor must be responsible for changes in the work made necessary from the installation of equipment other than the basis of design. Changes must be done without any additional cost to the Department or delay to project completion.

The Variable Frequency Controller with solid-state by-pass starter must be mounted in the MCC as shown on the plans and must meet the full load ampere requirements of the pump motors provided.

The Drive must have manual bypass capability using a solid-state reduced voltage starter where shown. The solid-state reduced voltage starter must be by Square D, or approved equal by Rockwell Automation or Benshaw

Engineering modifications required to meet the Specifications and plans must be provided by the manufacturer only. Modifications performed by third parties must not be accepted.

4.19.3.2. **Description**. Only drives suitable for operating the indicated loads must constitute an acceptable product offering. The Drive must conform to requirements of NEMA Specification ICS 3.1. The Drive must fit in the space shown on the plans.

4.19.3.3. **Ratings**.

- The drive must accept an input voltage plus or minus 10%.
- For drives greater than 5 HP, the displacement power factor must range from 1.0 and 0.95 lagging, over the entire speed range.
- **Efficiency**: minimum of 97% at full load speed.
- **Environmental ratings**:
  - Storage ambient temperature range: -40°C to 70°C (-40 to 158°F)
  - Operating ambient temperature range: 0°C to 40°C (0 to 109°F) without derating.
  - The relative humidity range is 5% to 95% non-condensing.
  - Operating elevation: up to 1000 Meters (3,300 ft) without derating.
- **Output Power Ratings**:
  - The output voltage must be adjustable from 0 to rated motor voltage.
- The output frequency range must be adjustable from 0 to 320Hz.
- The inverter section must produce a pulse width modulated (PWM) waveform using latest generation IGBTs.
- **Sizing**:
  - Loads must be as required to serve the equipment provided.
- Normal duty must provide 110% overload capability for up to 1 min. and 150% overload capability for up to 3 sec.

- Heavy duty must provide 150% overload capability for up to 1 min. and 200% overload capability for up to 3 sec.
- Normal duty must be provided unless otherwise indicated.
- **Definitions**:
  - The Drive Unit must refer to the actual drive that will be mounted within the specified enclosure.
  - The Drive System must refer to the drive unit and items specified under Drive System Options.

4.19.3.4. **Drive Unit Design**.

- Hardware
  - Use diode or fully gated bridge on the input.
  - Use line reactor on all ratings.
- Use switching logic power supply operating from the DC bus.
  - Incorporate phase to phase and phase to ground MOV protection.
  - Use gold plated plug-in connections on printed circuit boards.
  - Microprocessor based inverter logic must be isolated from power circuits.
- Use latest generation IGBT inverter section.
- Inverter section must not require commutation capacitors.
- Employ interface common for all horsepower ratings. Interface must include an LCD digital display, programming keypad and operator key options.
- Main Control Board must be common for all ratings.
  - Control connection must be common for all ratings.
  - Common Node Capacitors available on all frames.
- Control Logic
  - Ability to operate a drive with motor disconnected.
  - Provide a controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit. Provide annunciation of the fault condition.
  - Use an adjustable PWM carrier frequency within a range of 1-6kHz.
  - Provide either Selectable Sensorless Vector or V/Hz modes.
- The drive must be suitable for use on either normal duty or heavy-duty loads. If specified for normal duty, the drive must provide 110% overload capability for up to one minute and 150% overload capability for up to 3 sec.. If specified for heavy duty, the drive must provide 150% overload capability for up to one minute and 200% overload capability for up to 3 sec..
  - Provide multiple programmable stop modes including—Ramp, Coast, DC-Brake, Ramp-to-Hold and S-Curve.
  - Provide multiple acceleration and deceleration rates.
  - Make adjustments with the door closed.
  - The drive must have an adjustable output frequency up to 60Hz.
- Power Conditioning:
  - The drive must be designed to operate on an AC line which may contain line notching and up to 10% harmonic distortion.
  - An input isolation transformer must not be required for protection from normal line transients. If line conditions dictate the use of a transformer, the K factor must be 4.0 or less.

4.19.3.5. **Drive Unit Features**.

- Control Module
  - Selectable sensorless vector or V/Hz mode selectable through programming.
  - The sensorless vector mode must use motor nameplate data plus motor operating data such as IR drop, nominal flux current and flux up time.

- The volts per hertz mode must be programmable for preprogrammed fan curve, straight line, or full custom patterns.

- Current Limit
  - Programmable current limit from 0.1 amps to 150% of drive rated amps.
- Current limit must be active for drive states: accelerating, constant speed and decelerating.
- The drive must employ PI regulation with an adjustable gain for smooth transition in and out of current limit.
- Acceleration/Deceleration
  - Accel/Decel settings must provide separate adjustments to allow either setting to be adjusted from 0 sec. to 3600 sec..
  - A second set of remotely selectable Accel/Decel settings must be accessible through digital inputs.
- Speed Regulation Modes
  - Open Loop
  - Slip Compensation with speed regulation from 0.1 to 0.5%.
  - Process PI control
- Speed Profiles
  - Programming capability must allow the user to produce speed profiles with linear acceleration/deceleration or “S-Curve” profiles that provide changing accel/decel rates.
  - S-Curve profiles must be adjustable.
- Adjustments
- A digital interface must be used for set-up, operation, and adjustment settings.
  - Adjustments must be stored in nonvolatile memory (EEPROM).
  - No potentiometer adjustments must be required.
  - The drive must provide EEPROM memory for factory default values.
- Process PI Control
  - The drive must incorporate an internal process PI regulator with proportional and integral gain adjustments as well as error inversion and output clamping functions.
  - The feedback must be configurable for normal or square root functions. If the feedback indicates that the process is moving away from the setpoint, the regulator must adjust the drive output until the feedback equals the reference.
  - Process control must be capable of being enabled or disabled with a hardwire input. Transitioning in and out of process control must be capable of being tuned for faster response by preloading the integrator.
  - Protection must be provided for a loss of feedback or reference signal.
- Fault Reset/Run
  - The drive must provide up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart.
  - The automatic mode must not be applicable to a ground fault, shorted output faults and other internal microprocessor faults.
  - The time between restarts must be adjustable from 0.5 sec. to 30 sec..
- Skip Frequencies
  - Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance must be provided.
  - The set points must have a bandwidth adjustable from 0Hz to 60Hz.
- Run on Power Up: A user programmable restart function must be provided to automatically restart the equipment after restoration of power after an outage.
- Inertial Ride Through:
  - The drive must respond to a loss of AC input power by adjusting the output frequency to create a regenerative situation in the motor.

- The regenerated energy must recapture the mechanical energy and convert it to electrical energy that must power the drive logic during the power outage.

- The drive must retain control of the motor during the power outage.
  - The performance must be based upon the amount of system inertia and the length of the outage.
  - The amount of voltage drop required to trigger inertia ride through and the level at which regulation occurs must be adjustable.
  - Inertial Ride Through must be capable of being enabled or disabled vial programming.
- Fault Memory
  - The last eight fault codes with respective time must be stored in a fault buffer.
- Information about the drives condition at the time of the last fault such as operating frequency, output current, dc bus voltage and 28 other status conditions must be stored.
  - A power up marker must be provided at each power up time to aid in analyzing fault data.
- The last eight alarm codes must be stored, without time stamp, for additional troubleshooting reference.
- Overload Protection
  - The drive must provide internal Class 10 or 20 motor overload protection investigated by UL to comply with N.E.C. Article 430.
  - Overload protection must be speed sensitive and adjustable.
  - A viewable parameter must store the overload usage.
- Auto Economizer
  - An auto economizer feature must be available to automatically reduce the output voltage when the drive is operating in an idle mode (drive output current less than programmed motor FLA). The voltage must be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage.
  - When the load increases, the drive must automatically return to normal operation.
- Terminal Blocks: Separate terminal blocks must be provided for control and power wiring.
- Flying Start: The drive must be capable of determining the speed and direction of a spinning motor and adjust its output to “pick-up” the motor at the rotating speed.
- Ride Through: The control logic must be capable of “riding through” a power outage of up to 2 sec. in duration.
- Inputs and Outputs:
  - The standard Input/Output board must consist of both analog and digital I/O.
  - No jumpers or switches must be required to configure inputs and outputs. All functions must be fully programmable.
  - The Input/Output board must have the following analog inputs as standard: Minimum quantity of 2 differentially isolated plus or minus 10V (bi-polar) / 20mA, 9 bit plus sign, by common mode noise rejection. One input must be provided from the Primary PLC and one input must be provided from a Secondary PLC. A discrete input must be provided, as detailed below, to allow for selection of one of the above signals to be used for speed reference/control. Analog inputs must be user programmable for a variety of uses including frequency command and process loop input. Analog inputs must be user programmable for function scaling (including invert), offset, signal loss detect and square root.
- The Input/Output board must have the following analog outputs as standard: Quantity 2 differentially isolated plus or minus 10V (bi-polar) / 20mA, 9 bit plus sign. One output must be provided to the Primary PLC and one output must be provided to the secondary PLC. The analog output must be user programmable to be proportional to one of fourteen process parameters including output frequency, output current, encoder feedback, output power. Programming must be available to select either absolute or signed values of these parameters.
  - The Input/Output board must have the following digital inputs as standard: Quantity of 6 digital inputs rated 115Vac. Inputs must be individually programmable for functions from a list of 31 that includes Start, Run, Stop, External Fault, Speed Select, Jog and Process PI functions. One input

must be provided and programmed to allow for selection of the speed reference/control signal from either the Primary PLC or the Secondary PLC as detailed above.
    - The Input/Output board must have the following digital outputs as standard: Two relay outputs, form C (1 N.O. —1 N.C). Contact output ratings must be 250Vac / 30Vdc (2.0 Amps maximum), resistive or inductive. Relays must be programmable to 28 different conditions including Fault, Alarm, At Speed, Drive Ready and PI Excess Error. Timers must be available for each output to control the amount of time, after the occurring event, that the output relay actually changes state.
- Reference Signals: The drive must be capable of using the following input reference signals: Analog inputs, Preset Speeds, Remote Potentiometer, Digital MOP, Human Interface, Communication Module Commands.
- Loss of Reference: In the event of loss of reference signal, the drive must be user programmable to the following: Fault the drive, alarm and maintain last reference, alarm and go to preset speed, alarm and go to minimum speed, alarm and go to maximum speed, or alarm and maintain last output frequency.
    - Metering: The following metering parameter must be accessible through the Human Interface: Output Current in Amps. Output Voltage in Volts, Output Power in kW, Elapsed MWh, DC Bus Voltage, Output Frequency, Last 8 faults, Elapsed Run Time.
- Faults: Fault information must be accessible through the Human Interface. At a minimum, the following faults must be displayed: Power Loss, Undervoltage, Overvoltage, Motor Overload, Heat Sink Over Temperature, Maximum Retries, Phase to Phase and Phase to Ground Faults.

4.19.3.6. **Drive System Options**.

- Enclosure
    - NEMA 1G with washable metal mesh filters on the outside of the enclosure door and over other vented openings
    - Paint: Manufacturer's standard.
    - Top entry and bottom exit for power cables.
- Provide a 6.25 in. × 2 in. door mounted white Lamacoid nameplate with black letters (message to be defined during submittal).
- UL Label for UL panel recognition.
- Drive System Input Circuit Breaker. Provide a door interlocked circuit breaker disconnect.
- Drive input line reactor: Provide a drive input line reactor mounted within the drive system enclosure. The line reactor must meet the following: be iron core with an impedance of 5%, have copper windings, have Class H insulation with 115°C rise, and be rated for system frequency and voltage.

4.19.3.7. **Manual Bypass with Reduced Voltage Starting**. Provide means to manually switch a single motor from drive control to bypass (across the line) operation with soft start.

Microcomputer must analyze the motor variables and generate control commands that control the motor to reduce the possibility of surges occurring in the system.

- The starting time must be adjustable from 2 to 30 sec.
- The stopping time must be adjustable from 2 to 120 sec.
- Provide separate contactors for drive output, RVSS output and total bypass. The total bypass contactor must be used to bypass the RVSS once the motor is up to speed and must be capable of starting and operating the motor if so wired in the field. The contactors must be electrically interlocked.

Provide a door mounted VFD/Bypass selector switch and pilots lights for indication of VFD and Bypass modes of operation.

Provide a Class 10 overload for motor protection while operating in the bypass mode.

Provide a door mounted emergency stop pushbutton with red mushroom head and maintained contacts to deenergize the load in any operating mode.

Implement pump controls according to the schematics shown on the plans; including incorporation of the necessary devices to monitor pump overtemperature, seal failure or RTD's, as required, in coordination with the System Supplier and Pump Manufacturer.

4.19.3.8. **Control Power Transformer**. Provide a control power transformer mounted and wired inside of the drive system enclosure to supply enough control power for the VFD, the bypass controller and auxiliary instruments (pressure switches, etc.), as shown on the plans.

The transformer must be rated for drive, bypass, and auxiliary instrument power plus 250VA spare capacity for future customer use.

4.19.3.9. **Common Mode Choke**. Provide a common mode choke at the drive output to help, in conjunction with the proper grounding techniques, reduce or eliminate interference with sensitive electronic equipment or communication devices installed in the same system.

4.19.3.10. **Harmonic Mitigation Techniques**.

- None required if the VFD is below 100HP.
- Provide VFD with Active Front End for drives 100HP and above.

4.19.3.11. **Auxiliary Relays**. Provide relays for Drive Alarm, Drive Fault and Drive Run. Provide two additional relays to be wired per custom requirements.

The relays must be Allen-Bradley 700HC24A1 relays (2 form C contacts, 2N.O. & 2N.C.), Square D, or approved equal. The relay contacts must be rated for 1I5VAC/30V DC, 5.0 Amp resistive, 5.0 Amp inductive.

- Control Interface
  - The control terminals must be rated for 115V AC.
  - Inputs must be optically isolated from the drive control logic.
- Hand-Off-Auto Selector Switch.
  - Provide a "Hand/Off/Auto" selector switch for start-stop control.
- The devices must be Allen-Bradley Bulletin 800T pilot devices (30 mm, NEMA Type 4/4X/13) mounted on the drive system enclosure door.
- Pilot Lights
  - Provide pilot lights, mounted on the enclosure door, for indication of Run, Stop and Drive Fault.
  - Pilot lights must be LED illumination type with push to test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12–130V DC/AC power, and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Generally, color caps must be red for "run" and green for "stop" or "off." Unused colored shrouds must be provided to the Engineer to allow for future customization and configuration of pilot light colors as desired or required by the Department.
  - Pilot Lights must be Allen-Bradley Bulletin 800T, Square D, or approved equal. Provide NEMA Type or Type 4X as required or approved equal Pilot Lights.
- Motor Run Time Meter and Event Counter
  - Provide a digital, non-resettable, door-mounted elapsed time meter.
  - The meter must be electrically interlocked with the Drive Run relay and Bypass contactor (if required) to indicate actual motor operating hours.
  - Provide resettable door mounted event counter.
- Human Interface Module

- Provide a door-mounted Human Interface Module with integral display, operating keys, and programming keys.
- The Human Interface must be rated IP66 / UL Type 4X, 12.
- The display portion must have the following features: The display must be a 7 line by 21-character backlit LCD display with graphics capability.
- The display must show drive operating conditions, adjustments, and fault indications.
- The display must be configured to display in three distinct sections. The first section must be a status display for direction, status, fault or alarm conditions and Auto/Manual mode. The second section must display drive output frequency. The third section must be configurable as a display for either programming menus/information or as a two-line user display for two additional values utilizing scaled units.
- The Human Interface must provide digital speed control.
- The keypad must include programming keys, drive operating keys (Start, Stop, Direction, Jog and Speed Control), and numeric keys for direct entry.

4.19.4. **Execution**.

4.19.4.1. **Quality Control**. The vendor's manufacturing facility must be certified to the ISO-9001 series of standards from the International Standards Organization.

Inspect and test incoming material for conformance to the Specifications. The manufacturer must employ a vendor certification program to assure the quality of incoming materials.

Inspect and test subassemblies for conformance to Specifications.

Dynamically test control printed circuit boards for at least 22 hr. while heat cycled 1 hr. at each temperature setting from 0°C (32°F) to 60°C (140°F).

Subject drives to a Run-In Test with a properly sized motor and operated under cycling load conditions on a dynamometer. The Drive must be subjected to a Run-In Test that brings the Drive to full rated temperature.

Supplied drives must be Qualification Tested and must meet at least minimum testing for shorted output, capacitive coupling, chattering relay and showering arc.

The drives must carry an all-inclusive, 5-yr. parts and labor warranty from the manufacturer, and the warranty must include travel and other miscellaneous expenses.

4.19.4.2. **Start-up Commissioning Services**. Start-up will be performed at the user's site. The service division of the VFD manufacturer must perform start-up services. VFD manufacture must provide at least two days of onsite start-up service for each VFD. The use of third-party supplier start-up personnel is not acceptable.

The installation Contractor must coordinate with the supplier to provide the following.

- A pre-installation meeting with the user to review the following: site ready condition checklist provided by the VFD manufacturer and completed by the installation Contractor, the start-up plan, the start-up schedule, the drives installation requirements.
- Inspect the drives mechanical and electrical devices enclosed.
- Perform a tug test on internal connections within the drive and verify wiring.
- Verify critical mechanical connections for proper torque requirements.
- Verify and adjust mechanical interlocks for permanent location.
- Confirm sectional wiring is connected properly.
- Re-verify control wiring from any external control devices.
- Set up drive internal power supplies and thyristor control circuits.

- Verification of proper phasing from isolation transformer to drive.
- Confirm cabling of drive to motor, isolation transformer and line feed.
- Perform Megger test.
- Apply voltage to the drive and perform operational checks.
- Bump motor and tune drive to the system attributes. (If the load is unable to handle any movement in the reverse direction, the load should be uncoupled before bumping the motor for directional testing.)
- Run the drive motor system throughout the operational range to verify proper performance.

4.19.4.3. **Standard Testing**. Perform the following tests in conformance with applicable requirements and specifications of Canadian Standards Association (CSA), Underwriters Laboratories (UL), National Electrical Manufacturers Association (NEMA), European Standard (EN), and International Electrotechnical Commission (IEC).

Perform functional checks wherever possible; otherwise, inspection and continuity checks must be made.

Component devices must be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.

Instruments, meters, protective devices, and associated controls must be functionally tested by applying the specified control signals, current, and voltages.

Inspect drives for the following.

- Control power failure test,
- Rectifier gating checks,
- Inverter gating checks,
- Link converter tests,
- Machine converter tests, and
- Load tests: Drives must be accelerated to the test motor's nominal frequency, under load, decelerated to 10 Hz, then accelerated back to test motors nominal frequency, with a ramp time of approximately 10 sec.. This cycle must be repeated continuously for up to one hour. Drives must be tested under load at the test motor's nominal frequency.

4.19.4.4. **Physical Inspection**. The product must meet applicable engineering and workmanship standards and Specifications. Verify components against engineering documentation to be present and correctly installed.

Warning plates, isolation barriers, and mechanical interlocks must provide enough safety isolation for personnel and equipment.

- Warning labels and nameplates must be present and in their specified positions to advise personnel of possible hazards.
- Isolation barriers must be in place within the cabinet. Such barriers protect personnel from touching live components in an area that otherwise does not have power supplied to it.
- Operation of isolation switch handle and door interlocks must be verified. The interlocking prevents the opening of any medium voltage door on a medium voltage cabinet when the isolation switch handle has been moved to the full "ON" position.

Bus and bus connections must be checked for proper clearance, creepage, phasing, and torque.

4.19.4.5. **Witness Testing**. VFD supplier must make the VFD available for witness testing by the Department's representatives, Witness test must include a drive system run test that must consist of operating the variable frequency drive connected to a dynamometer. During the testing of the drive, a demonstration of the operator interface and functionally will be provided as well as demonstration of the operation of the drive. The drive will be tested up to rated horsepower at both steady state and varying speeds. VFD supplier must notify the

Engineer four weeks in advance of testing date. At the conclusion of testing, the Engineer's representative will convene with the VFD manufacturers Application Engineer or Project Manager to discuss any concerns or issues that arose during the test. Any modifications or changes requested by the Department will be addressed at this meeting.

A review of the electrical and mechanical drawings for the purchased equipment must be done with the Suppliers Application Engineer or Project Manager before commencing the tests. Any questions or clarifications, before commencing the test, will be addressed at this time.

A Certified Test Report must be issued to the Purchaser at the conclusion of the testing.

4.19.4.6. **Warranty**. VFDs and RVSSs must carry an all-inclusive five-year parts and labor warranty from the manufacturer from the date of Substantial Completion. The warranty must cover all components. The warranty must include travel and other miscellaneous expenses.

4.20. **Control Panels**. In so far as the requirements are applicable, provide control panels, control panel components, and control panel modifications performed under this Contract in accordance with this Specification. Unless otherwise indicated, control panels and control panel modifications must be provided by the System Integrator and must be complete and include components and wiring as shown on the plans and specified herein.

New control panels to be provided under this Contract include, but are not limited to, the following.

- Station Pump Control Panel (PCP)–See Specification for additional information,
- Manufacturer Packaged Pump Controller (PPCs) See Specification for additional information,
- Level Control Panel (LCP),
- Sludge Pump Control Panel,
- Control components provided integral to the MCC,
- Test Simulation Panel,
- Local Control Stations, and
- Generator Auxiliary Control.

Work to the Pump Control Panel include, but are not limited to,

- Development of programming for the PLC, associated OIT/HMI, and communication modems;
- Installation of PLC CPU unit;
- Provision of Ethernet Switch for integration of the Sludge Pump PPC, Strom Water PPC, Generator, ATS, building security, test simulation panel, field I/O into the PLC;
- Provision of 24 VDC Power Supply, UPS unit, and associated Batteries;
- Provision and programming of communication modems and integration with the existing RTU; and
- Integration of signals for the Pumps, ATS, VFDs, PPCs, Level Controller, and MCC into the PLC and Auxiliary Operation Control Loops.

Requirements of control components identified in this section apply to the entire project and not limited to any particular control panel.

Furnish labor and materials required for providing remote access and I/O communication between the stations as shown on the plans and Specifications. Data links are currently provided between the pump station and the existing SCADA. The Contractor is responsible for the configuration of the modems and coordination with the telecom provider to ensure that modems are correctly configured and installed to provide transmission and reception of currently existing I/O and additionally specified I/O.

4.20.1. **Quality Assurance**.

Regulations and Standards:

UL	Underwriters' Laboratories
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
ANSI	American National Standards Institute
IEEE	Institute of Electrical and Electronic Engineers
ISA	Instrument Society of America

The control panel components must be of the most current and proven design. Specifications and plans call attention to certain features but do not purport to cover all details entering the design of the control panels. The components provided by the System Supplier must be compatible with the functions required and must form a complete working system.

The control panels must be UL listed as a complete assembly in accordance with UL-508A.

Guarantee. Control panels must be guaranteed in writing for defects in materials and workmanship for a period of 2 yr. from the date of substantial completion. The warranty must be comprehensive, and must include parts, labor, travel, and other miscellaneous expenses.

4.20.2. **Submittals**. Submit shop drawings on the control panels in accordance with the requirements of the Instrumentation Section. Shop drawings must be complete and must include a complete bill of material, catalog information, descriptive literature for all components, UPS load studies, wiring diagrams, and panel layout drawings showing dimensions to other devices.

4.20.3. **Products**.

4.20.3.1. **Control Components**. Before being installed or implemented on field equipment, the final modified program must be simulated on the new PLC CPU. Perform complete closed loop checks for I/O to verify complete functionality of the new PLC CPU. Following installation and field testing, the final program must be copied onto the spare PLC CPU which will then be turned over to the Department.

4.20.3.2. **Control Panel Enclosure**. Control panel enclosures must be designed and sized in conformance with the requirements of the plans and the Specifications.

Where required, additional freestanding enclosures must be NEMA 12, constructed of Type 316 stainless steel with continuously welded seams. Panel must have piano type hinged, overlapping doors with neoprene gasket. Enclosure doors must be equipped with a heavy-duty 3-point latching mechanism operated by a padlocking handle.

Where required, additional wall mounted enclosures must be NEMA 12, constructed of 14-gauge Type 316 stainless steel with continuously welded seams. Panel must have piano type hinged doors with neoprene gasket.

Properly identify control panel components with an engraved nameplate mounted on the inside of the panel. Components not mounted on the front of the panel must be mounted to a subpanel. Install wiring in a neat workmanlike manner and must be grouped, bundled, supported, and routed horizontally and vertically to provide a neat appearance. Terminate wires leaving the panel at the terminal strips inside the enclosure. Identify terminals and wires in conformance with the Supplier's panel wiring diagrams.

Provide a copper grounding plate inside the control panel for terminating ground wires.

Provide a plastic data pocket inside the control panel.

4.20.3.3. **Enclosure Light Fixture**. Supply low profile LED light strip fixtures with the appropriate location and quantity of light fixtures to ensure adequate and full illumination of enclosed components but at least what is required to span across 2/3 width of the panel. Individual light fixtures must have an operating temperature of -22 to 140°F, provide 900 LM illumination, and have 5-watt power draw. The light fixture must be Hoffman Part Number LED24V15 with appropriate power supply for installation in unclassified environments or equivalent by Halo. Fixtures within classified environments must be Hoffman Product Series LEDHL24V or equivalent by Halo.

4.20.3.4. **Enclosure Cooling Fan and Exhaust Grills**. Provide a cooling package for the control panel. The cooling system must be sized to keep the panel temperature below the maximum operating temperature of the equipment housed. A thermostat located in the control panel must control the cooling system. The cooling system must be Hoffman, nVent, or approved equal.

4.20.3.5. **Control Circuit Breakers**. Circuit breakers must be quick-make, quick-break thermal magnetic molded case type individually mounted and identified. Circuit breakers must be Allen-Bradley Bulletin 1492-CB, Omega, or approved equal by Moeller.

4.20.3.6. **120 VAC Uninterruptible Power Supply (UPS)**. Provide 120VAC Tower UPS units for the Pump Control Panel and Sludge Pump Control Panel.

Furnish UPS units with an alarm contact to indicate when the UPS is operating on battery power and when the UPS has failed or requires maintenance. Alarms must be monitored by the PLC's.

Supply UPS units with a built-in USB port and 6 built in UPS supported outlets. UPS units must include the optional bypass (PDU) that enables replacing the UPS with a "hot-swappable" replacement unit with no disruption to connected equipment.

Size UPS to power 100% of the full panel load from 1-hr.

The UPS must be Tripp Lite Model BCPRO. No substitutions must be accepted.

4.20.3.7. **24 VDC Uninterruptible Power Supply (UPS) and Batteries**. Provide 24 VDC UPS units as indicated for each group of equipment on the plans and as specified within the individual equipment specifications.

The UPS must be din-rail mounted and furnished with an alarm contact to indicate when the UPS is operating on battery power and when the UPS has failed or requires maintenance. Alarms must be monitored by the Pump Control Panel PLC's.

UPS batteries must be valve regulated, spill proof construction, allowing safe operation in any position. Batteries must have rugged impact resistant ABS case and cover (UL94-HB) and must be UL recognized.

UPS must be rated for 0 Amps to 15 Amps output current at 24 VDC. Batteries must be 12 VDC with 40 Amp-Hours of capacity.

The UPS must be rated for 0°C to 60°C and batteries must be rated for up to 0°C to 50°C.

The UPS must be SITOP 24 VDC UPS, Model 6EP1 931-2EC42 by Siemens with high temperature battery. Batteries must be PS-12400 by Power-Sonic Corporation.

4.20.3.8. **Unmanaged Ethernet Switch**. Provide an unmanaged DIN rail mounted Ethernet switch for installation in the Pump Control Panel to expand the number of available RJ-45 Ethernet ports and allow for integration of the Motor Protection devices or systems, pump electronic modules, building systems, and power monitoring

components provided as part of the Automatic Transfer Switch and the MCC into the PLC at the Pump Control Panel. Switches must have the characteristics as shown below:

Table 1
Switch Characteristics

Input Power:	Redundant 10-30 VDC
Humidity:	10% to 95% (Non-Condensing)
Operating & Storage Temperature:	-40°C to 85°C
Mean Time Between Failure:	>2 million hours
Ports:	16 10/100BaseTX RJ-45 Ports
Humidity:	10% to 95% (Non-Condensing)
Operating & Storage Temperature:	-40 C to 85°C

Switch must have IEEE 802.3 Compliance, ESD and Surge Protection on Built-in Ports, and have Autosensing 10/100BaseTX, Duplex, and MDIX. Switch must be provided with a serial configuration port and must have Bi-Color Status LEDs For Link, Speed, Activity & Duplex. Switch must be the N-TRON 316TX-N 16-Port Unmanaged Industrial Ethernet Switch by Redlion, Phoenix Contacts, or approved equal.

4.20.3.9. **Selector Switches**. Supply selector switches that are 30.5 mm heavy-duty non-illuminated. Switches must have double-break silver contacts. Switches must be maintained contact type unless otherwise indicated on the plans. Provide auxiliary contact blocks on switches where indicated on the plans or in the Description of Operation. Provide a gray legend plate for each switch with white marking as indicated on the plans. Selector switches must be Allen-Bradley Bulletin 800T NEMA Type 4, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.10. **Push Buttons**. Push buttons must be 30.5 mm, heavy-duty, non-illuminated. Push buttons must have double-break silver contacts. Push buttons must be momentary contact type) color-coded as indicated on the plans. Push buttons must have flush heads. Provide a gray legend plate for each push button with white marking as indicated on the plans. Push buttons must be Allen- Bradley Bulletin 800T, NEMA Type 4.

4.20.3.11. **Pilot Lights**. Pilot lights must be LED illumination type, heavy duty with push-to-test lamp test option provided and wired. Pilot lights must be suitable for use with universal 12-130V DC/AC power, and provided with translucent shrouds to allow for configuration of the light in the appropriate color. Pilot lights must have a nominal diameter of 30mm for installation in 30.5mm openings. Unused colored shrouds must be provided to the Department with each control panel to allow for future customization and configuration of pilot light colors as desired or required by the Department.

Pilot Lights must be Allen-Bradley Bulletin 800T, NEMA Type 4/4X and 13 as required, or equivalent by Phoenix Contacts, or approved equal.

Pilot Lights for installation in NFPA defined hazardous locations and classified areas must be Allen-Bradley Bulletin 800H, Type 4, 7, & 9, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.12. **Relays**. Relays must be heavy-duty general-purpose type with 10-amp contacts. Relays must have terminals, which plug-in to a socket, mounted to the inside of the panel enclosure. Terminals for relays with AC coils must be pin type, and terminals for relays with DC coils must be blade type with number of poles as required.

Relay coils must operate on 120 volts AC, unless indicated otherwise on the plans. Relays must have an indicator light to indicate the relay coil is energized. Furnish relays by Idec RR Series or equivalent by Phoenix Contacts.

Supply 4-pole main input relays for field devices with outputs assigned as shown on the plans.

Relay inputs, including coil wiring, must be wired through terminal blocks. Outputs must be 24 volts to interposing relays. No direct wiring will be allowed to relays or PLC output cards.

4.20.3.13. **Intrinsically Safe Relays**. Provide intrinsically safe relays as required by applicable electrical codes.

The intrinsically safe relay must be a single channel repeater with a DPDT set of output contacts and must operate on 120 volts AC.

The intrinsically safe relays must be Stahl I.S., Isolators Type 9170, or equivalent by Phoenix Contacts.

4.20.3.14. **Intrinsically Safe Barriers**. Provide an intrinsically safe barrier in the control panel as required by applicable electrical codes. The intrinsically safe barriers must be Stahl, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.15. **24 Volt DC Power Supplies**. The new 24 VDC power supply for the Pump Control Panel must be DIN rail mounted and must be integrated with the new UPS and batteries specified above to provide battery backed up 24VDC to the components within the Pump Control Panel. Power Supply must be capable of receiving 85-132 / 176-264 VAC power (115/230 VAC, Auto Selecting) and providing 24 DC at 10 Amps (240W). Power supply must be rated for operation from -10°C to 60°C and have a mean time between failures of greater than 600,000 hours. 24 VDC power supply for the Pump Control Panel must be Model SDN-10-24-100P by Sola or approved equal.

4.20.3.16. **Single Level Terminal Blocks**. Provide terminal blocks in each control panel for terminating field wiring. Provide terminal blocks rated for 600 volts AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Terminal blocks for 24 VDC inputs must be blue.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-W4, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.17. **Two Level Terminal Blocks**. Terminal blocks must be provided in each control panel for terminating field wiring. Provide terminal blocks rated for 300 volts AC and must be identified with a permanent machine printed marking in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-JD3, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.18. **Three Level Terminal Blocks**. Provide terminal blocks in each control panel for terminating field wiring. Supply terminal blocks rated for 300 volts AC and identified with permanent machine-printed markings in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare terminal blocks in the control panel.

Terminal blocks must be Allen-Bradley Bulletin 1492-JT3M, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.19. **Fuse Holders**. Provide fuse holders in each control panel as required. Supply fuse holders rated for 300 volts AC and identified with a permanent machine-printed markings in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare fuse holders in the control panel.

Fuse holders must be Allen-Bradley Bulletin 1492-H6, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.20. **Grounding Blocks**. Provide grounding blocks in each control panel as required. Supply grounding blocks identified with a permanent machine-printed markings in conformance with the terminal numbers shown on the panel wiring diagrams.

Provide 20% spare grounding blocks in the control panel.

Grounding blocks must be Allen-Bradley Bulletin 1492-JG3, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.21. **Wiring Ducts**. Provide wiring ducts to manage path of wire and cable inside the enclosures. Provide-back wire retention to trap wires during installation. Ducts should meet a UL 94V-0 Flammability Rating, UL Component Recognized.

4.20.3.22. **120VAC TV Surge Suppressors**. Surge Suppressors must be Allen Bradley, or approved equal with the following features.

- Max Surge Current: 40 kA/phase,
- Housing Rating: NEMA 4X, non-metallic enclosure,
- Connection Method: Parallel, #10 AWG Stranded Wire,
- Provided with thermal fusing,
- Diagnostics: Green Status LED, Audible Alarm, and
- UL 1449 2nd Edition Listed.

Mount Surge Suppressor inside the control panels.

4.20.3.23. **Alarm Lights**. Alarm lights must be continuous intensity, amber, and sealed in a watertight enclosure. Alarm lights must be Patlite model PS-24 with a rubber gasket, or equivalent by Phoenix Contacts, or approved equal.

4.20.3.24. **General-Purpose Signal Multiplier**. General-purpose signal multiplier must provide isolated input, two outputs, and power supply. Device must split the input signal into 2 output signals. The device must have the following features: DIN rail mounted; green power LED to indicate that the supply voltage is present; accepts #14-#24 AWG solid or stranded wiring; requires 18-30VDC power supply; and provides 4-20mA input and two sets of 4-20 mA outputs.

General-purpose signal multiplier must be a Phoenix Contact MCR signal multiplier, or equivalent by Allen Bradley, or approved equal.

4.20.3.25. **Industrial Backup PSTN and Leased Line Modem**.

- Modem must have the following ports:
  - One Public Switched Telephone Network (PSTN) Port
  - One Leased Line (LL) Port
  - One RS-422/485 Port
  - One RS-232 Port
- Modem must be rated for a temperature range of -13°F to +158°F and relative humidity, non-condensing range of 5 to 95%.

- Modem must be designed to operate from 12 to 48 VDC or 12 to 27 VAC power source.
- Modem must provide data rates up to 33.6 kbits/sec. over both PSTN and 2- or 4-wire lease line circuits and data rates up to 115.2 kbits/sec. over the RS-422/485 and RS-232 protocols.
- The Industrial backup PSTN and Leased Line Modem must be Westermo TD-36 485, LV (Low Voltage) or equivalent by Data Connect or approved equal.

4.20.3.26. **Wiring**. See Instrumentation and Control Wiring for supplemental information. Wiring must be stranded copper, 14-gauge, 600-volt, Type MTW. Power wiring must be 600-volt, Type MTW, sized as required. Splices are not permitted.

Analog signal wiring must be 18-gauge twisted pairs with foil shield and drain wire, with 600-volt, 90°C insulation. Drain wires must be grounded at one end only.

Isolate wiring and terminal strips by voltage levels to the greatest extent possible.

Wiring must conform to the following color code.

- 120 volts, 1 phase: Black, White;
- 24 VDC: Blue;
- 120 VAC Control Wires: Red;
- Interlock control circuits energized from external source: Yellow; and
- Ground Wires: Green.

120 VAC control wires energized from a source external to the control panel power source must be yellow.

Wiring for intrinsically safe circuits must be purple.

Tag control wiring at each end with a legible permanent coded wire-marking sleeve. Sleeves must be white PVC tubing with machine printed black marking. Markings must be in conformance with the wire numbers shown on the control wiring diagrams and must match terminal strip numbers.

In panels where foreign voltages exist, furnish a highly visible warning label outside the panel with the following words:

“WARNING: POWER FROM OTHER SOURCES EXIST IN THIS PANEL.
THEY ARE IDENTIFIED BY YELLOW WIRE COLOR.”

Warning label must be red with white lettering.

4.20.3.27. **Nameplates**. Provide laminated phenolic nameplates on the front of each control panel. Nameplates must be black with white engraved letters. Engraving must be as indicated on the plans. Minimum size of engraving must be 1/4 in.

4.20.3.28. **Spare Parts**. Provide the following spare parts.

- 3 Selector Switches of each type and model specified and provided.
- 5 pushbuttons of each type and model specified and provided.
- 5 pilot lights of each type and model specified and provided.
- 3 Relays and associated sockets of each type and model specified and provided.
- 20 terminal blocks of each type and model specified and provided.
- 5 fuses and fuse blocks or holders of each type and model specified and provided.

4.21. **Instrumentation and Communication Wiring**. Provide electrical wiring needed to complete the Instrumentation Systems specified elsewhere in this Item and as shown on the plans.

work covered by this section includes, but is not limited to, providing the following.

- Conduit raceways for signal cables;
- Conduit raceways for AC power circuits;
- Signal cables and coaxial cables;
- Branch circuit (power) cables;
- Terminal cabinets, junction and pull boxes;
- Equipment connections; and
- Category 5e cable (Ethernet & Telephone).

Contractor must provide raceway systems, cables, and conductors from transmitters and sensing devices, etc. to instrumentation panels, terminal panels, etc. as shown on the plans and specified in instrumentation and control divisions in the Specifications or required by the equipment manufacturer.

4.21.1. **Submittals**. Submit shop drawings for the following.

- Terminal cabinets,
- Power cables,
- Signal cables,
- Junction and pull boxes, and
- Category 5 cable.

4.21.2. **Coordination**. Coordinate the work as specified herein with work to be performed and equipment furnished under other Divisions of the Specifications to ensure a complete and satisfactory control and instrumentation installation.

4.21.3. **Wire and Device Coordination**. Each wire must be labeled and numbered around the wires at each termination of the wires at relays, terminal boards, and other devices. Wire labels must use a legible permanent coded wire-marking sleeve. Sleeves must be white PVC tubing with machine printed black marking. Wire numbers must correspond to wire numbers on the wiring and loop diagrams.

Identify cabinets and instruments by the same letter or number combinations used on the elementary wiring diagrams. Identification must be by means of white laminated bakelite nameplates with 1/4 in. engraved black lettering. The nameplates must be fastened to the device or to the panel just below the device by stainless steel self-tapping screws.

In panels where foreign voltages exist, furnish a highly visible warning label outside the panel with the following words:

“WARNING: FOREIGN VOLTAGES EXIST IN THIS PANEL.
THEY ARE IDENTIFIED BY YELLOW WIRE COLOR.”

Warning label must be red with white lettering.

4.21.4. **Products**.

4.21.4.1. **General**.

- Wiring must be stranded copper.
- Wiring and terminal strips must be isolated by voltage levels to the greatest extent possible.
- Wiring must conform to the following color code.
  - 120 volts, 1 phase: Black, White;
  - 24 VDC: Blue;
  - 120 VAC control wires: Red;
  - Interlock control circuits energized from external source: Yellow;

- Ground wires: Green;
- 120 VAC control wires energized from a source external to the control panel power source must be yellow; and
- Wiring for intrinsically safe circuits must be purple.

4.21.4.2. **Terminal Cabinets**. Terminals in cabinets, panels, etc. for instrument wiring must be miniature type with captive clamps to facilitate attachment of minimum size 14 AWG, rated for 600 volts. Terminals must have continuous marking strips.

4.21.4.3. **Power Cables**. Size power cables as shown on the plans and must be multi-conductor Type TC rated for 600 volts and must have crosslinked filled polyethylene or ethylene rubber insulation over Class B stranded copper conductor groups covered with overall polyester film type and with an overall thermoplastic jacket. (Coding must be ICEA, Method 1).

4.21.4.4. **Signal Cables**. Analog (4-20 mA) signal circuit wiring must be one, twisted shielded pair of 16 AWG instrumentation cable. Each tinned copper conductor, made up of 19 strands of 20 AWG wire must have color coded insulation. Two insulated conductors must be twisted together in an overall aluminum-polyester 100% coverage shield. Must allow for 2 to 50 conductors per cable. Cables must be run continuous without splices from transmitters to receivers or terminal cabinets. The shielded conductors, along with a stranded, bare 16 AWG drain wire must be rated at 600 volts; must bear the UL-TCER label as a recognized component of UR210. Each individual pair must be shielded and the entire multi-conductor cable must also be shielded.

Digital signal cables must be multi-conductor twisted pairs. Conductor sizes and number of pairs must be as shown on the plans or as required by the manufacturer of the signal equipment. Must allow for 2 to 50 conductors per cable. Cables must be run continuous without splices from transmitters to receivers or terminal cabinets. Cable must be multi-conductor THWN UL-TC-ER wiring.

4.21.4.5. **Communication Cables**. Profibus Cabling must be 600V UL-TC0-ER IS/OS 2118A cabling with gauge size and pair count as required. Modbus RTU cabling must be 3 and 4 wired version as necessary to provide a complete and fully functional system.

Connections between PCs, Modbus devices, Profibus devices, network switches and control network must be made using Category 5e Shielded Twisted Pair solid cable with PVC jacket and shielded RJ-45 connectors, unless otherwise specified. Use shielded Twisted Pair stranded cable for those links that may be subjected to repeated flexing.

Meet the following requirements:

Wiring Type:	Category 5e, TIA/EIA 568C
Impedance:	100 ± 15 Ohms
Conductor Gauge	24 AWG
Cable construction:	4 pair, PVC jacket, solid or stranded conductors.
Connectors:	RJ45, shielded
Frequency:	Up to 1 GHz
Shield:	Copper braid, covering 4 pairs and connectors. Shield connected to external drain wire.

Cat 5E cables must be Data DataTuff Cat 5e 600V AWM-rated Cable by Belden, Square D or approved equal.

Factory terminated cables must be provided, except as listed below. Maximum length is 300 ft., for communication links of greater lengths fiber must be used with appropriate switches and media converters. Field terminated (bulk) cable is only permissible for the following.

- Cables terminated on terminals of field instrument or control devices, and
- Cables that leave a building.

Telephone Cables: Provide Category 5E Cable with RJ-45 connectors for telephone applications where specified.

4.21.5. **Execution**.

4.21.5.1. **Grounding**. Ground wires in conformance with requirements of the Electrical Specifications.

4.21.5.2. **Installation of Wire and Cable**. Install wire and cable per requirements of Electrical Specifications.

Shield Grounding: Each signal shield must have only one grounding point which must be located at the source of the signal, (e.g., analog transmitter) unless otherwise recommended by the instrument or equipment manufacturer. Shields must be continuous through cabinets, panels, etc.

Terminations: Terminate wire at both ends of the power and signal cables with pre-insulated solderless spade or ring lugs and in conformance with the requirements of the Control Panel Specification. Spare conductors must be terminated on marked terminal strips or connector pins at each end.

Only pull wires and cables once. Wires and cables which are pulled in one direction and retracted, must be replaced with new wires and cables at no additional cost.

No splices will be permitted.

4.22. **Process Control Strategies**.

4.22.1. **Panel Description**. A pumping system consisting of a motor control center (MCC), variable frequency drives (VFD), station Pump Control Panel (PCP), reduced voltage solids state starters (RVSS), primary transducer, secondary back-up floats, signal booster-duplicator (SB), programmable logic controller (PLC), local control stations, existing remote telemetry unit (RTU), level Control Panel (LCP), manufacturer packaged pump controllers (PPCs), and test simulation panel must be provided for the pumping station.

Manufacturer Packaged Pump Controllers (PPCs): PPCs must be provided by the pump manufacturer. Separate PPCs must be provided for the sludge pump and main storm water pumps: SWP-1 and SWP-2, and Sludge Pump-1 The PPCs must control and monitor the provided pumps. Manufacturer PPC must be provided with integral operator interface terminals and communicate with local hand stations for LOCAL/OFF/AUTO interlocks.

Provide a separate local control station enclosures for SWP-1, SWP-2, and Sludge Pump-1.

Locate the PPCs for the main storm water pumps:SWP-1 and SWP-2, in the station Pump Control Panel (PCP).

Locate Sludge Pump-1 PPC in a separate control panel and required to interface with the PCP and local control station.

Provide a Level Control Panel (LCP) to aggregate and duplicate field analog 4-20 mA and discrete level indications. The LCP must communicate level information to the sludge pump PPC, main storm water pumps PPC, and PLC located in the station PCP.

4.22.2. **Station Pump Control Panel (PCP)**. Provide a station PCP with a PLC to communicate with:

- Main Storm Water Pump PPC,
- Sludge Pump PPC,

- Human Machine Interface (HMI),
- SWPS: 1, and 2 VFD/SSRVS,
- Level Control Panel,
- Generator Auxiliary Panel,
- Automatic Transfer Switch,
- Building Security and HVAC,
- Fire Alarm,
- Intrusion Switches,
- Existing RTU, and
- MCC.

The PLC must be provided with input/output (I/O) modules to communicate via digital-discrete, analog, ethernet, modbus-TCP as necessary to communicate with the equipment and location. Final determination of equipment and communication protocol must be the responsibility of the Systems Integrator.

Provide PLC as manufactured by Allen Bradley, Schneider Electric, or approved equal.

The PCP must have primary and backup communications with the pumping system manufacturer PCPs. Primary communication must be high-speed communications via Modbus/CATe. Back-up communications must be hardwired analog and discrete signals. Upon loss of primary communication, the PLC must automatically use hardwired I/O. Evaluation must include but not be limited to evaluating and replacing the enclosure, power supplies, I/O cards, modemed, power supplies, switches, communication cards, networks switches, replays, and applicable appurtenances necessary to meet the requirements of the Contract Documents.

Existing Remote Terminal Unit RTU: The Systems Integrator must evaluate the existing RTU to determine its suitability for reuse. The Systems Integrator must be responsible to expand or modify the existing RTU I/O platform to communicate with the new PCP and the existing TxDOT SCADA system.

4.22.3. **Pump Station Control Panel**. A pumping station control panel (PCP) must be provided in the pumping station control room to house manufacturer packaged pump controllers (PPCs) a programmable logic controller (PLC), human machine interface (HMI) or operator interface terminal (OIT), digital displays, and other associated controls for the pumping station equipment. The PCP must provide automatic control, process, and alarm monitoring for the station Operator Interface

Provide 15 in. HMI/OIT PCP and Sludge Pump Control Panels manufactured by Harmony GTU, Magelis GTU, or approved equal. The HMI/OIT should include the necessary HMI software, drives, and other development tools to provide a complete and functional system in conformance with the plans and Specifications.

The PPC programmable operator interface must be mounted on the pumping station control panel. The sludge pump PPC must be provided a standalone enclosure. The operator interface must be programmed to perform the following functions.

- Display Graphic Screens of the Pumping Station,
- Display Process Variables,
- Display Alarm Messages,
- Display Setpoint Screens,
- Trend Wet Well Levels, and
- Trend Pumping Station Flows.

The operator interface must be a color touch screen, which must be networked to the PLC system via Ethernet.

4.22.3.1. **Programmable Controller Software**. Programmable controller programming and documentation software must be provided to enable a workstation to be used to view, edit, program, document, and communicate with the PPC's and station PLC.

4.22.3.2. **General Systems Requirements**. The complete pumping control system must be provided by the pump manufacturer. The pumping manufacturer must be responsible for coordination and communication to provide a complete and functioning system in conformance with the plans and Specifications.

The PPC's must have independent, field adjustable, level control set points for each pump start and stop and alarm notification set points. The PPC must control the pump station using the water level measured by the Primary Level Transducer unless one of the following alarms occurs.

- Low Water Level Alarm is triggered via the Primary Level Transducer analog signal and associated set point within the PPC.
- High Water Level Alarm is triggered via the Primary Level Transducer analog signal and associated set point within the PPC.

If one of the above alarms occurs, the level control for the pump station must switch to operation via the back-up float system. The PPC must continue to use the back-up float system for level monitoring and control until the Primary Level Transducer is re-enabled by pressing the "Reset" pushbutton on the Pump Control Panel.

In the back-up float mode of operation, the VFD must operate at the operator selected speed or full speed if in SSRVS Mode.

If either the Low-Level Float or the High-Level Float are triggered and maintained for set periods of time during any of the operational modes detailed above the PCP must trigger a common alarm and enter the Backup Relay/Float operation mode. In this mode the PPC will start and stop the mains stormwater pumps via hardwired control logic and will no longer use the PLC or Level Transducer for station operation or control.

Backup Relay/Float operation must use hardwired time delay relays and must operate independently of the PPC. This mode of operation extends to failure in the PCP. Backup Relay/Float operation must function as follows:

The PCP must contain a time delay relay for each of the four pumps. Upon initial triggering of the high-level float the time delay relays must be energized. As an individual float is triggered and the associated field configurable delay time relay has elapsed, the PCP must start the pump. The time delays must be initially configured to allow individual, sequential starting of the pumps.

Following deactivation of the high-level float, pumps that were called to run must remain running until the individual float is no longer triggered. Pumps must have an adjustable restart timer applicable in all modes of operation.

- When the low-level Float is triggered, pumps must be called to stopped under all operational modes such as Back-Up Relay/Float, Primary Level transducer, and PPC, operational modes.
- Back-Up Relay Float mode must only be applicable for the main storm water pumps.

Any station alarm can be disabled at the station through the local HMI. The alarm disable function must be password protected so that only designated personnel can disable the station alarms. When there is an alarm present at the station it must be displayed on the OIT screens.

The PPC must have an output that will be energized any time there is an alarm present at the station.

Install 1 Primary Level Transducer to sense the level in the wet well and provide automatic control of the pumps. The Transducer must output a 4-20mA analog signal proportional to the wet well level to the PCP and PLC for level monitoring.

Install Backup Relay/Floats in the wet-well for automatic control of the pumps independent of the PPC.

4.22.3.3. **Pump Motor Controls**. The pump motor controls should include the following.

- A variable frequency drive (VFD) and reduced voltage solid state starter must be provided for each of the main storm water pumps. The VFD will be the primary mode of operation. The Operator must manually select the SSRVS mode of operation at the MCC.
- An embedded VFD and manufacturer provided PPC must be provided for the sludge pump.
- The AUTO position of each pump H/O/A selector switch must be wired to allow for remote starting of the pump via the MCC.
- Each pump H/O/A switch must have an auxiliary normally open contact that must close when the switch is placed in the AUTO position. This contact must be wired to the PPC.
- Each VFD and RVSS must have a run contact that must close when the starter is energized and providing power to the pump motor. This contact must be wired to a run indication light and elapsed time meter on the MCC enclosure, and a run relay located inside the enclosure.
- Each VFD and RVSS must have a fault contact that must be wired as an input to the PPC.
- The run status and fault alarm for each VFD and RVSS must be input to the PPC.
- Lock-out stop push buttons (maintained type) must be on the station PCP enclosure or where shown on the plans. The stop buttons must be wired in series with the pump control circuit so that when a stop button is pushed in, power to the control circuit must be disconnected.

4.22.4. **Description of Operation**. The pumps must be controlled by the individual H/O/A selector switches located on the MCC, PCP and Local Station. The HAND and OFF positions of the H/O/A selector switches provide for manual start/stop control of the pumps. In the HAND position, the pump start sequence must begin. In the OFF position, the pump stop sequence must begin.

When the pump H/O/A switches are in the AUTO position, the pumps must be automatically started and stopped by the PPC in response to the wet well level as follows:

Program level setpoints in main storm water pump PPC for the following levels.

- Wet Well High-Level,
- Lead Pump Stop,
- Lag 1 Pump Stop,
- Lead Pump Start,
- Lag 1 Pump Start, and
- Wet Well Low-Level.

Program level setpoints in sludge pump PPC for the following levels.

- Sludge Pump Stop,
- Sludge Pump Start, and
- Wet Well Low-Level.

The level setpoints must be adjustable via the operator interface located in the main storm water pump and Sludge Pump PPCs.

Program the operator interfaces to enable the Operator to select whether the pumps must be controlled by the primary transducer or secondary back-up floats.

Any Mixed Flow Axial Impeller Pump can be selected as the Lead or Lag in Lead-Lag sequence.

The pump alternation must be based upon selection of the Lead or Lag pumps.

The Operator must select the Lag pump order from the operator interface. Any pump must be able to be assigned to any position in the operational door.

The Operator must select the mode of alternation from the operator interface. The three alternation modes are Lag Pump Alternation, Time Alternation, and Manual Alternation.

4.22.5. **Process Control Strategy**. When the level in the wet well rises to the elevation of the Sludge Pump Start level setpoint, the PPC must start the Sludge Pump. When this level is reached, a start delay timer in the PPC must be started. When this timer times out, the PPC must start the Sludge Pump.

If the Sludge Pump cannot keep up with the influent flow, the level in the wet well must rise to the Lead Main Pump Start level set point. When this level is reached, a start delay timer in the PPC must be started. When this timer times out, the PPC must start the Lag Main Pump. If the level is above the Lead Main Pump Stop level, the Lead Main Pump and Sludge Pump must run continuously.

If the Sludge Pump and Lead Main Pump cannot keep up with the influent flow, the level in the wet well will rise to the Lag Main Pump Start level set point. When this level is reached, a start delay timer in the PPC must be started. When this timer times out, the PPC must start the Lag Main Pump. If the level is above the Lag Main Pump Stop level, the Lag Main Pump, Lead Main Pump and Sludge Pump must run continuously.

The operating pumps will be lowered to minimum speed before starting additional an additional pump. The called pump will be started at minimum speed and the Lead and Lag pump speed will be increased simultaneously to mitigate surges in downstream flow.

When the level in the wet well is pumped down to the Lag Main Pump Stop level set point, the PPC must shut down the Lag Pump at minimum speed.

When the level in the wet well is pumped down to the Lead Main Pump Stop level set point, the PPC must shut down the Lead Pump at minimum speed.

When the level in the wet well is pumped down to the Sludge Pump Stop level set point, the PPC must shut down the Sludge Pump.

For each pump, the current number of starts and current runtime hours must be calculated in the PLC for the current 24-hr. period. These values must roll into yesterday's number of starts and yesterday's runtime hours after the current 24 hr. period expires.

When the PLC senses a loss of power, it will remove the run signal to the pumps after a time delay that is set at the OIT. When the power returns, the pumps will start one at a time. There will be a time delay for each pump start so that the pumps are staggered on a restart. These delay times must be set from the OIT.

When the PLC senses a blip in power, it will remove the run signal to the pumps. After a time delay that is set at the OIT and the pumps are in the ready state, the pumps will start one at a time. There will be a time delay for each pump start so that the pumps are staggered on a restart. These delay times must be set from the OIT.

If the level in the wet well is drawn down to the Wet Well Low-Level setpoint, a timer in the PPC must be started. If this timer times out and the Low-Level condition still exists, the PPC must shutdown pumps. When this occurs, a Wet Well Low-Level alarm message must be displayed on the operator interfaces. This condition must also cause the Back-up floats to take control of the station as previously described.

If the level in the wet well rises to the elevation of the Wet Well High-Level setpoint, a timer in the PPC must be started. If this timer times out and the High-Level condition still exists, a Wet Well High-Level alarm message must be displayed on the operator interfaces.

The PPC's must provide failure monitoring for each pump as follows.

When a pump H/O/A switch is in the AUTO position and the pump gets signal to start, a failure timer in the PLC's must be started. If this timer times out and the pump VFD or across the line starter is not running, a "Pump Failure" alarm message must be displayed on the operator interfaces.

If a pump is taken out of AUTO, or experiences a failure or fault, the PPC's must index the lead/lag assignments of the pumps so that this pump is moved to the LAG position. The failed pump must be locked out of the pump sequence until it is placed back in AUTO or its alarm has been cleared.

The following alarms for each of the pumps must be displayed on the operator interfaces located on the control panel.

- Pump Overload,
- Pump Not In Auto,
- Pump Fail to Start,
- Pump Over Temperature,
- Pump Seal Failure,
- Power Monitoring,
- General Description, and
- TVSS device must be provided for the Pump Control Panel to protect the system from transient voltages that may occur due to lightning or surges on the incoming power line. Description of Operation:

The TVSS devices must be furnished with a normally open alarm contact. This contact must be wired to the PLC. If a TVSS alarm occurs, this contact must close, and a TVSS Alarm message must be displayed on the operator interfaces.

4.22.6. **Uninterruptible Power Supply (UPS)**. Furnish a UPS with a normally open contact that must close when the UPS is operating on battery power. This contact must be wired to the PLC's. When normal power fails and the UPS is operating on battery power, a timer in the PLC should start. If this timer times out and the UPS is still on battery power, a "UPS on Battery Power" alarm message must be displayed on the operator interfaces located on the pumping station control panel.

Furnish a UPS with a normally open contact that must close when the UPS battery power is low. This contact must be wired to the PLC. If the battery power becomes low, a timer in the PLC must be started. If this timer times out and the UPS battery power is still low, a "UPS Battery Power Low" alarm message must be displayed on the operator interfaces.

Furnish 120V UPS units for the Pump Control Panel and Sludge Pump Control Panel. The units must be sized to provide 1-hr. of operation at full load and provided with alarm contacts to indicated when the UPS is operating on battery pawer and when the UPS has failed or required maintenance. Alarms must be monitored by the PLC.

4.22.7. **Operator Interface**. Mount a programmable operator interface on the control panel to display alarm messages and process values, and to enable the operator to change process setpoints in the PLC.

Whenever an alarm occurs, a corresponding alarm message must be displayed on the operator interface as previously described in the description of operation. If more than one alarm is present, the alarm messages must scroll with each message being displayed for 3 sec.

An alarm message must remain in the system until its corresponding alarm is cleared.

4.23. **Process Control and Instrumentation for Sludge Pump—Manufacturer Packaged Pump Controller (PPC)**. The pump manufacturer must provide a control panel for the Sludge Pumping System the must interface with the Pump Control Panel. This system will include, but is not limited to, the following.

- Communications gateway for each Pumping System (CPS),
- Pump station controller capable of controlling sludge pumps with integral pumps,
- Remote monitoring equipment compatible with the manufacturer's remote monitoring system,
- Surge protection,
- Automatic Pump Cleaning,
- Pump Blockage,
- Time Based Pump cleaning,
- Modular expansion and configuration,
- Commissioning of the control panel, and
- Site acceptance testing (SAT).

4.23.1. **References**.

- UL 508A and 698A
- NFPA 70 - NEC (2017)
- NFPA 820
- ISA 5.1 and 5.4
- ISA/IEC 62443-4-1
- ISA/IEC 62443-4-2
- IEC 60870–5 104

4.23.2. **Submittals**. Submittals must include but are not limited to the following.

- Shop drawings,
- Bill of Material (BOM),
- Wiring diagrams,
- Outline and dimension drawings, and
- Enclosure mounting details.

4.23.3. **Delivery, Storage, and Handling**. Deliver, store, protect and handle products to site under provisions of this Item. Store in a clean, dry space. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

4.23.4. **General Requirements**. The Pump System manufacturer must design and build the control panel.

4.23.5. **Installation**. Installation must be in conformance with manufacturer's instructions. Perform electrical work performed full conformance to the requirements of the Electrical Specifications.

4.23.6. **Warranty**. When installed in accordance with this Specification and related sections, the warranty against defects in materials and or workmanship on the control panel must be 7 yr. (84 mo.) from Substantial Completion. The warranty must be in printed form, included with the product submittal, and previously published as the manufacturer's standard warranty for similar units manufactured.

4.23.7. **Products**.

4.23.7.1. **Monitoring and Control Products**. Pumping System Controller (Nexcon, Miltismart or Approved Equal). The station controller must have the following features, at a minimum.

- Hand-off auto switch for each Pumping System (CPS),
- User configurable liquid level setpoints for CPS activation and deactivation,
- User configurable liquid level alarm setpoints for high level,

- Alternation options include Lead/Lag,
- Inputs and outputs: 4 zero-volt digital inputs,
- 4 relay outputs rated at 250V or 30VDC, 5 amps, and
  - 1 analog input 24VDC max
  - 1 analog output 24VDC max.
- Sludge Pump Modules. Provide modules as necessary to provide functionality and communication as described on the plans and Specifications.
  - Set power, set speed, and displayed current.
  - Automatic start when the power is turned on.
  - Soft start and stop.
  - Energy minimizer.
  - Pipe flushing at pump cycle start.
  - Automatic pump cleaning
  - Pump blockage
  - Time based pump Cleaning
  - Dry run protection
  - Leakage and overheating protection
  - Motor protection

At a minimum the pump control system must be provided with the following modules.

- Sludge Pump modules,
- VFD module,
- Backplane supply modules,
- Probe module,
- Digital I/O,
- Analog I/O,
- Station Manager, and
- Security.

The following station optimization features must be pre-configured:

- Fat buildup minimization feature that uses a random lead pump start delay timer. The timer must be initially set to 60 sec.
- A sump and pipe cleaning function that will run the CPS to the snore point based on an operator configurable number of pump cycles. The number of cycles must be initially set to 11.
- The CPS must automatically detect a blockage and automatically clear the blockage. The station controller must monitor the status and annunciate an alarm should the blockage not be cleared.
- The station controller must have an energy minimizer function that minimizes the amount of energy used per pumping cycle.
- Integrated data logger with
  - Capacity for recording up to 4,000 events
  - Ability to download events to a USB storage device
- Monitoring of output current, power level, speed, and motor temperature
- Faults on the controller must be configurable for
  - Acknowledgement Required
  - Three levels of priority
  - Automatically resetting fault
- Human Machine Interface (HMI). A display compatible with the pump station manager and must have the following features at a minimum. The home screen displayed parameters must include:
  - Pump status for each pump including:

  - Pump running.
  - Pump is in the HAND position.
- Pump is in the OFF position.
  - Pump is in the AUTOMATIC position.
  - Pump is available to run.
  - Pump fault
- Pump alternation active indicator.
- High inflow control

Information Screen that shows the following information.

- Hours Run counter for each pump:
  - total time today, total time yesterday
  - total time this week
  - total accumulated hours since last commissioning
- Pump Start counter for each pump:
  - pump starts today, pump starts yesterday
  - pump starts this week, total accumulated pump starts
  - power in kW
- I/O Status:
  - Digital I/O status
  - Analog I/O status with a value in mA

Ability to configure the controller without a laptop and configure the following parameters at a minimum.

- Set point programming of pump activation or deactivation values and level alarm values,
- Enable/Disable level alarms, faults, and historical data recording,
- Configuration of Inputs and Outputs,
- Configure station optimization parameters,
- Configure communications parameter,
- Create or restore backup copies of the pump controller configuration settings, and
- Factory reset the controller.

Supply a 7 in. touchscreen display may be supplied, instead of, or in conjunction with the keypad display, and must have the following features at a minimum.

- Built in web browser,
- Multi-touch screen,
- Dual core process @ 8MHz,
- 512 MB Flash and 1GB Ram,
- Fan-less design,
- IP65 front panel,
- Power: 12-24VDC @8.5W,
- Resolution: 800×480, and
- Operating temperature: 0-60°C.

Pumping system gateway

- Each pump must be equipped with one pump gateway which must offer at least following interfaces: 1 x USB, 1 x RS485 1 x Ethernet RJ 45 1 x Display interface, 4 x Digital outputs, 4 x Digital inputs, 1 x Analog input & output.
- It must supply the following pump data.
  - Start and stop commands,

- Power consumption information,
- Operating speed,
- Running status, and
- Fault information.

- The housing must be isolated according to protection class IP 20 applicable to operate in ambient temperature: -20˚C to +60˚C.
- It must be applicable for 24 VDC Power supply.
- The pump gateway must allow to control of the pump through I/O or Modbus RTU or TCP.
- It must have emergency run relay functionality which secures that the pump will operate when the main controller fails.
- The unit must be tested and approved in conformance with international standards CE, UL, RCM and CSA and be designed and manufactured by the pump supplier.

4.23.7.2. **Level Sensor (Flygt LTU 801, equivalent by Endress and Hauser, or approved equal)**. The sump must be equipped with a Multi-Stage Level Sensing device or a Level transmitter designed to detect level of the wastewater for pump control and liquid level display.

The Multi-Stage Level Sensing Device must be PVC injected to seal the unit and prevent any moisture from entering any of the sensor units. Each sensor on the probe must be rotated 90° horizontally from the previous sensor along the probe length to eliminate tracking between sensors. Level sensing probes must be pressure injected with an epoxy resin at final assembly to encapsulate internal components and connections, thereby creating a rigid, sealed, homogeneous unit. Two wires must be included within the length of the probe and must be connected to each other at the bottom of the probe. When the wires are connected to the Pump station Controller, the connection must provide fail-safe monitoring of the probe cable and the probe assembly. The flexible cable used for the Level Sensing Probe must be comprised of PVC/PVC multi-conductor construction with a common oversheath that is water and oil resistant. The multi-conductor cable must be identified with numbering and text along the entire length of the outer sheath at required intervals.

The Level transmitter must measure the relative pressure with a ceramic diaphragm and be approved acc. EN 61000-6-2, EN 61000-6-3, EN 61326-1. It must be insulated > 100 MΩ at 500 V DC and the sensor body must be made of Ryton PPS.

The sensors installed in the sump must be approved for explosive areas according UL Class 1, 2 and 3 Division 1 Group A-D T4/T5/T6

Cables must be secured to the top of probe bodies by synthetic rubber compression fittings for strain relief. The cable must be rated to physically support the combined weight of the sensor and long enough to reach to reach the cable connection box.

Provide a stainless-steel mounting that includes a wiper device that allows maintenance personnel to clean the level sensing probe when necessary.

4.23.7.3. **Float Switch**. Provide cable float switch suitable for indoor or outdoor installation. It must be capable to operate automatically to indicate tank level, start or stop pumps, or actuate level alarm signals.

The float switch and piping must be submersible. A junction box must be provided near the float to allow for ease of removal and replacement. The junction box must be minimum NEMA 4X and float switch must be IP 68 rated. Components must be listed as suitable for the hazardous area classification in which they are to be installed. Construction must have material compatible with the application. For floats installed in process areas, do not locate the Junction Box in the wet well or enclosed process area.

Provide proper mounting for the float switch and cable to ensure that the float switch is secured and that there are no obstructions within a tank to prevent the full extension of the cable in either direction. Provide adequately designed 316 stainless steel pole or stainless-steel weighted chain and weight for each float to

allow for the removal, replacement, and adjustment of the floats without entering in the tank and allow for secure mounting within the tank or process area during operating conditions.

The base bid price must be for a complete float switch system including, but not limited to, sensor, cable, enclosure, power supply, intrinsic safety barrier, signal conditioner, pipe mount clamps, and other hardware and accessories as required by manufacturer for a complete and fully functional system.

Provide, install, program, and calibrate each float switch system in areas shown in the Contract Documents. Ensure that Instruments is tagged and calibrated in conformance with PID diagrams, Instrumentation Layout, and Individual Equipment Specifications.

- Type: Mercury free ball float switch.
- Function and Performance
  - Differential: Switch must activate when the process level rises no more than 4'' above the fixed mounting position and deactivates when the level decreases to no more than 4'' below the fixed mounting position.
- Switch Rating: 1 amp at 120 VAC or 100 VA at 120 VDC.
  - Provide NO or NC type contact for fail safe operation.
- Physical
- Float: 316 Stainless Steel, Teflon or nonstick coating, minimum 5 in diameter.
  - Totally encapsulated switch.
  - Cable must be heavy duty, PVC, or equivalent jacketed integral to float.
- Accessories Required:
  - Provide stainless steel hardware.
- Lead wire must be a waterproof cable of enough length so that no splice of junction box is required in the vault.
- Provide cast-aluminum weatherproof junction box outside the sump pit with terminals for floats and tapped as required for conduit connections.
- Manufacturer: Siemens Water Technologies, Contegra, or approved equal.

4.23.7.4. **Backup UPS system**. Provide a 24VDC power supply with battery backup capable of running al DC loads for at least 1 hr.

4.23.7.5. **Surge suppression**. Supply a 240VAC or 480VAC three-phase surge suppression device must be installed in line with the supply voltage with the following features.

- Each input must have a nominal AC operating voltage of 240V for 240V supply or 277V for 480V supply,
- Meet UL 1449 4th edition requirements,
- Meet IEC 61643-11 requirements,
- A response time of less than 1 ms,
- Nominal discharge current: 20kA 8/20 µs,
- Maximum discharge current: 50kA 8/20 µs,
- Maximum surge capacity: 60kA 8/20 µs,
- Voltage protection rating: 1000V (240V) or 1500V (480V),
- Voltage protection level: 1300V (240V) or 1700V (480V),
- Residual voltage at 10kA (8/20 µs): 1395V,
- Operating frequency range: 0-500Hz, and
- Operating temperature: -104ºF to +185ºF.

4.23.7.6. **Hazardous Location Protective Device**. The Hazardous Area Protective Device is intended to protect equipment and personnel in areas where hazardous conditions may be present.

Supply an intrinsically safe device according to the following specifications:

- The intrinsically safe barrier must be panel mounted and designed to protect a ball float inputs and level transducer inputs.
- The barrier must be certified intrinsically safe for use with equipment in installations up to and including Class 1, Zone O.
- The intrinsically safe barrier must have screw terminals for wire connections.
- The intrinsically safe barrier must be protected and current limited according to the requirements of UL Class I (Groups A, B, C & D), Class II (Groups E, F, & G) and Class III certification.
- The device must also be CE and CSA listed for applicable locations and must allow a maximum short circuit current of 10 ma.
- The intrinsically safe barrier must be surface mounted using the mounting flanges on either side of the unit assembly.
- The unit must be fastened with approved screws or bolts in conformance with UL requirements.

4.23.7.7. **Control Panel Construction and Assembly**. Control panels must be manufactured in accordance with the UL 508 standard or UL 698A and must be so constructed for the application of a UL listing label by an approved UL control panel assembly facility.

Install and arrange the control panel wiring must in an organized, efficient manner. Inspect control panel wiring for safety and verified by performing a point-to-point test.

Properly inspect and torque electrical connections in accordance with the UL 508 standard or UL 698A standard. External connections to the control panel must be by way of numbered terminal blocks.

Properly check and load test control panels with power applied. A control panel test log must be supplied with the control panel.

Provide control panels from a UL approved control panel assembly facility with the required labels properly attached.

Control panel enclosure environmental rating: Control panel enclosure rating must be specified in accordance with the project requirements or the plans as either NEMA 12 (painted steel) or 4x (stainless steel).

Wiring requirements:

- Wiring for AC and DC control circuits must be type sis or type MTW stranded copper and must be sized for the applied voltage and current. Unless otherwise noted, control circuit wiring must not be smaller than No. 16 AWG.
- Cable wiring for analog signal circuits must be twisted, shielded pairs of stranded copper conductors that must not be smaller than No. 20 AWG.
- Wiring for special signaling equipment such as communications, digital data, and multiplexed signals must be provided by the equipment supplier.
- Wiring must be numbered and marked at each termination point.
- Terminal blocks for internal or external wiring must be din rail mounted, individual screw compression type terminals with machine printed labels.

Grounding. Properly ground panel enclosure in conformance with the national electrical code and local code requirements.

Each analog signal loop must only have its shield wire connected to ground at a single point for the loop. Shields must be grounded at control panels where signals are input to the receiving device and not at the source of the transmitting device.

Local alarm (flashing light). There must be a flashing alarm light mounted on top of the control panel enclosure for local alarm indication. The flashing alarm light must be supplied according to the following specifications.

- UL recognized for use with UL NEMA type 4x &12 enclosures;
- Shatter resistant Lexan globe, UV Stabilized and flame retardant; and
- The flashing alarm light must be by Ingram products, equivalent by Phoenix Contacts, or approved equal.

Electrical transient (surge) protection. Protect electrical and electronic components of the control panel against damage due to electrical transients induced in interconnecting lines from lightning discharges and surges in nearby electrical systems.

The transient surge protector must be rated for 25ka per phase or larger.

Enclosure condensation heater. Provide a 120vac, 100-watt enclosure heater inside the control panel. The heater must be a silicone rubber, insulated strip type enclosure heater. The heater must be Hoffman, Hammond, or approved equal.

4.23.8. **Execution**. Perform installation in conformance with plans, Specifications, and manufacturers specifications.

4.23.8.1. **Examination**. A factory trained technician must examine the work area before beginning work and check the following.

- The environment is safe to begin working in.
- Surfaces are ready to receive work.
- Tools are in the proper location and are in good condition.
- Grounding of the system.

4.23.8.2. **Field Quality Control**. The following field tests must be performed by a factory trained technician.

- Point to point wiring verification,
- Utility power verification,
- Site acceptance testing, and
- System demonstration.

Point to Point I/O Verification. After installation of the pumps and the control panel, a factory trained technician must prepare the I/O checklist. The checklist must include the following.

- Inputs and outputs connected to the control panel,
- Alarms that can be generated by the control panel,
- The technician must follow a test procedure to test I/O and alarms, and
  - Digital inputs must be tested from point of origin unless it is unsafe.
  - Digital outputs must be tested by running a simulation test from the controller or by simulating the fault condition.
  - Analog inputs must be tested from the point of origin where possible and by use of a signal generator otherwise.
  - Analog outputs must be tested by running a simulation program or by forcing the output to a value.
- The technician must follow a test procedure to ensure the system operation parameters are met.

Configuration Verification. The factory trained technician must document the settings using a factory provided configuration checklist. Each parameter must be verified before the beginning of testing and then again after testing is completed.

Document the configuration of the pump station manager as well as the IPS gateways.

Save the pump station manager configuration to a factory provided SD card after testing is completed.

4.23.8.3. **Factory trained Supervision**.

- Procure a factory trained technician to check over equipment before putting the equipment into operation.
- Perform a point-to-point test of wiring.
- Perform a functional test of equipment alarms and controls.

4.23.8.4. **Certification of Testing**.

- Tests must be performed in the presence of a duly authorized representative of the Department. If the presence is waived, certified results must be provided by the Contractor.
- Written notice of tests must be given two weeks in advance.

4.23.8.5. **Test Equipment**. Provide test equipment.

4.23.8.6. **Training**. Training must be at least 4 hr. and cover the complete Pumping System and related controls. Instruction material must be provided for four trainees.

4.24. **Pump Control System for Main Storm Water Pump—Manufacturer Packaged Pump Controller (PPC)**. A packaged pump control controller must be provided by the pump manufacturer for the main storm water pumps. The packaged pump controller must be provided as part of the Pump Station Control Panel. The complete system must be coordinated by the pump manufacturer to provide a complete and functioning system.

The work in this Section must include furnishing and placing into operation the monitoring and control panel a pump station with submersible column pumps as shown on the plans.

The controller must alternate the pumps and operate the pumps always at its best efficiency.

4.24.1. **References**.

- Electrical work must be in conformance with Electrical requirements as specified and shown.
- UL 508A and 698A
- NFPA 70-NEC (2017)
- NFPA 820
- Canadian Underwriters Laboratory (CUL)
- ISO 9001 and ISO 140001

4.24.2. **Submittals**. Submittals must include, but not be limited to, the following.

- Shop drawings,
- Bill of Material (BOM),
- Wiring diagrams,
- Outline and dimension drawings, and
- Enclosure mounting details.

Delivery, storage, and handling. Deliver, store, protect and handle products to site under provisions of the plans and Specifications. Store in a clean, dry space. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

4.24.3. **Qualification Requirements**. The manufacturer must provide data on alternate equipment manufacturer's experience. Only Manufacturers with 20 or more years of experience who have furnished at least 20 similar lift stations that have been in regular operation not less than 5 yr. will be considered. Evidence of experience

and operational data may be required from the manufacturer to determine the suitability and efficiency of the equipment offered.

4.24.4. **Installation**. After installation, a pump station start-up must be performed by the installing Contractor under the supervision of the manufacture's authorized representative. Field service must be provided by an authorized, factory trained representative of the pump manufacturer. Services must include, but not be limited to, inspection of the completed pump station installation to ensure that it has been performed in conformance with the manufacturer's instructions and recommendations, supervision of field-testing and activation of the Pump Manufacturer's Warranty. The test must demonstrate to the satisfaction of the Department that the equipment meets specified performance criteria, is properly installed and anchored, and operates smoothly without exceeding the full load amperage rating of the motor. The Contractor must be responsible for coordinating the required field services with the Pump Manufacturer.

Perform electrical work in full conformance with the requirements of the Electrical Specifications and plans.

4.24.5. **Warranty**. When installed in accordance with the provisions of this Section, related Sections and the supplier's installation manual, the warranty on the Monitoring and Control equipment must be 12 mo. from date of Substantial Completion.

4.24.6. **Products**.

4.24.6.1. **Monitoring and Status**.

- The pump manufacturer must supply a Control system designed to monitor and control his pumps. The Monitoring system must be mounted in the cabinet and contain per pump 1 Base unit acting as a gateway between the Pump and the Central Monitoring and a Central Control Unit (CU). The CU must be able to control up to 10 Pumps.
- Each pump must be connected by just two controls leads to the base unit (BU). The control leads must be part of the Motor cable. An additional Pilot cable must not be allowed.
- The Base Unit (BU) must be able to stop the pump if required via an interlocking relay and it must provide connections for optional measuring modules such as a power meter and other I/O modules.
- The central unit (CU) must be provided for external access and information exchange with the monitoring system via one single point. The user should be able to connect to the CU via an RJ45 jack to Local PC point to point and Local area network.
- A local operator panel must be possible to connect to the CU via a separate RJ45 socket.
- The CU must have a functionality based on embedded web pages that can be used through a PC or operator panel that allows:
  - A graphical user interface for configuration and analysis via computer and HMI
  - Pump status overview
  - Alarm management
  - Analysis through trend graphs and histograms.
  - External communication with any SCADA via Modbus RTU or Modbus TCP
- The CU must contain the same pump data and logged data stored in each pump electronic module for quick access and redundancy.
- The system must support the service and maintenance policy that applies to the pump by generating service reminders and graphically providing users with an overview of service status that facilitates planning of upcoming service.
- The Cabinet must be equipped with HMI Touch panel for access and interaction with the Monitoring and Control system. The panel should be at least 15 in. in size and able to show color.
- When a pump related alarm is generated, the system must support the user in the form of:
  - Measurement data linked to the specific alarm item for analysis.
- Text information about possible root cause errors.

- Remedial actions.

4.24.6.2. **Soft starter (DANFOSS MCD 600, Square D, or Approved Equal)**.

- The soft starter must be provided by the manufacturer in configuration suitable for panel mounting or wall mounting. Power devices and components must be inaccessible during routine maintenance or set-up.
- The manufacturer must be able to provide the soft starter in a packaged NEMA 12 enclosure with fused disconnect, motor overload, remote keypad, and control power transformer.
- The soft starter must use a three-phase thyristor (SCR) bridge consisting of at least two SCRs per phase to control the starting and stopping of standard motors.
- The soft starter must incorporate a “self-cleaning” function to remove debris from the impeller. The cleaning function must consist of forced stopping, reversal and forward runs timed to allow for debris to fall from the impeller. After cleaning cycle is complete, drive must resume to automatic operation.
- The soft starter must provide current-feedback (closed-loop) control for linear acceleration without external feedback independent of motor load or type of application. The gating of the thyristors will be controlled in such a manner to ensure a smooth and stable acceleration ramp.
- The soft starter must operate by modulating the output voltage to maintain a user defined start current. Voltage ramp (“open loop”) and current limiting (voltage clamping) type soft starts are not acceptable.
- The soft starter must use Adaptive Acceleration Control which allows selection of different acceleration and deceleration profiles unique to application needs and be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCR’s.
- The soft start must be designed to operate in an ambient temperature from 0 to 104°F and applicable for following site conditions:
- Storage temperature from -10 to 140°F.
  - Relative humidity up to 95% at 104°F.
- Designed to operate in altitudes up to 3300 ft.
- Capable to operate without limitation between +10% and –15% of nominal voltage.
- The soft start must automatically adapt for operation at 50 to 60 Hz. Frequency tolerance must be +2% to –5% when starting and between +2% to –5% during steady state operation. A microprocessor controlled thermal protection system must be included which continuously calculates the temperature rise of the motor and soft start. It must also provide phase loss, phase reversal, under load, stall, and jam protection.
- The soft start must be capable of supplying 350% of rated full load current for 30 sec. 10 times per hour at maximum ambient temperature. The manufacturer must supply rating information and PC-based selection tools to determine the appropriate rating of the starter for the specific application. The Contractor must supply the appropriate data from the motor and driven load to the soft starter manufacturer.
- Dialog functions, display units, remote functions, terminal blocks, configuration switches must be accessible on the front of the control module. Exposure to control circuits during routine adjustments is prohibited.
- Digital indication must provide, as a minimum, the following conditions:
  - Soft start status - ready, starting, stopping, run.
- Motor status - Current, Thermal status. Fault status – Shorted SCR trip, Excess start time trip, Overcurrent trip, Motor thermistor trip, Phase imbalance trip, Supply frequency trip, Phase rotation trip, Instantaneous overload trip, Power circuit fault, Undercurrent trip, RS485 communications fault, EEPROM read/write failure. A Graphical LCD user interface must be used to configure the following operating parameters as required:
  - Motor full load amps adjustable from 50 to 130% of the controller rating.
  - Current limitation on starting adjustable from 10 to 550% of motor full load rating.

- Total start time adjustable from 1 to 255 sec.
  - Current limit adjustable from 10 to 550% of nominal motor current.
  - Selectable Torque boost.
- Selection of freewheeling/coasting, soft stop, or DC braking.
- Adjustable soft stop current ramp time from 1 to 100 sec.
  - Braking torque level adjustable from 30% to 100% effectiveness.
- Selection of Overload Class (2, 10, 10A, 15, 20, 25, or 30) must be integral to built-in motor thermal overload protection.
  - Selectable automatic reset operation.
  - Assignment of controller's inputs and outputs.
  - Activation of phase reversal protection.
  - Reset of motor thermal state.
  - Return to factory default settings.
- Three output relays configurable for, line contactor, Run, Tripped, High current flag, low current flag, Output on, DC brake contactor.

4.24.6.3. **Pump station controller**. The pump station controller must provide automatic control of the pumps with an HMI display interface.

- The minimum features available in the pump controller must include:
  - Pump control of up to six pumps; including pump grouping and pump alternation.
  - Intelligent Hand-Off-Auto Control for each pump from the main display keypad as follows:
  - Hand mode (semi-automatic, non-maintained manual mode), the pump switches off at the deactivation set point and then resets to Auto mode for the next pump run cycle.
- Hand mode (fully manual, maintained mode). To pump beyond the off (deactivation) set point, the Hand-Off-Auto button must be held down by the user for failsafe control.
- Level set point adjustment for pump activation, deactivation, and station level alarms.
- Level device inputs must include: 4-20mA analog signals, conductive probes, or floats.
- Redundant level device inputs with automatic fault control (input device switching).
- Selectable charge (fill) or discharge (empty) modes.
- Pre-configured station optimization features must include:
- Maximum pumps to run
  - Maximum starts per hour
- Maximum pump run time
  - Pump maintenance run function
- Pump alternation modes must include:
  - Standard alternation of pumps
  - Fixed sequence pump control
  - User defined alternation using a (N:1) or (N:M) ratio
  - Alternation based on the most efficient pump
  - Alternation by the number of hours run
- Alternation by the number of starts within a specified time period
- Pump decommissioning mode to allow one or more pumps to be fully decommissioned.
- Up to six unique user defined profiles of set points must be available to control pumps during specific site conditions or events. Features must include:
  - Automatic profile change based on date and time
- Profile selection option from SCADA (remote control), digital input, logic tag or local keypad
- Locked level alarm function to indicate a level device fault.
- Analog input signal watcher function to monitor analog input values for control and alarm uses.
- Level simulation function for pump station commissioning and general testing.

- A datalogger for user-defined faults and events must include:
  - Recording of up to 50,000 events to internal flash memory
  - Download capability up to 10,000,000 events in the form of a comma delimited file (CSV)
- Three phase supply voltage monitoring and supply fault management for the following conditions.
  - Under-voltage, Over-voltage;
  - Phase fail, Phase rotation;
  - Monitoring of dc power supply, battery voltage, and internal controller temperature;
  - Energy, power and pump efficiency monitoring;
  - kW, kVA, power factor, kWHr, KVAH calculation for each pump;
  - Pump efficiency calculation (gallons per KWHr) for each pump; and
  - Power supply data (voltage, frequency, and phase angle information).
- Motor fault protection features:
  - 3-phase current monitoring for each pump
  - Over current fault detection
  - Under current fault detection
  - Ground fault detection
  - Current phase imbalance fault
  - Motor insulation resistance failure detection
- Flow measurement: (when enabled by software key)
- Calculated flow by liquid level drawdown method
  - Flow monitoring by inputs from a flow meter (analog input and pulsed signal input)
  - Flow alarms for pumps and total station flow
- VFD speed control function (when enabled by software key)
- Fault handling functions:
  - Pump hold out function
  - Automatic reset function after fault condition is no longer present
- Manual reset of fault (if user intervention of fault reset is required)
- Remote control functions via remote telemetry: (when enabled with software key)
  - Change the operating mode of the pump (hand/off/auto operations)
  - Reset of pump faults and station faults
  - Change pump and alarm set point values
  - Change the operational profile of the pumps
- Security
  - User defined password management for access to programming areas in the controller
  - Automatic data logging of personnel who have entered the programming areas
- Automatic logging of unsuccessful login attempts with a date and time stamp
- Digital input option for controlled access to programming areas
- SD and USB media access ports must be available for the following operations:
  - Firmware upgrades
  - Saving or loading pump controller configuration information
  - Exporting or importing MODBUS and DNP3 points list information
  - Downloading data logs
- Advanced programming functions: (when enabled by software key)
- The pump controller must have the ability to be used with IEC61131-3 and IEC61499 compliant PLC programming languages to enhance or modify existing functionality.
  - Isa Graf software programming and Logic Engine scripting language must be supported.
- The pump controller must include a separate user interface (HMI display) keypad for configuration settings, control operations, and advanced programming. The following parameters must be displayed on the main screen:

- Liquid level in percent, meters, feet, inches, or other custom defined units
  - Set points for pump control and level alarms
  - Pump status (running, stopped or next to run)
- Pump availability indication
- Pump fault indication
  - 3 user configurable lines of information to display pump station status and data
- The main screen must include an INFO button to view the following pump station information:
  - Hours Run counter for each pump and the pump station to include:
    - minutes run for last pump cycle
    - total minutes (hourly)
    - total hours today, total hours yesterday
    - total hours this week, total hours last week
    - total accumulated hours
  - Pump Start counter for each pump and the pump station including:
    - pump starts this hour, pump starts last hour
    - pump starts today, pump starts yesterday
    - pump starts this week, pump starts last week
    - total accumulated pump starts
  - Flow values (when enabled by software key)
    - station inflow rate
    - pump flow rate
    - total station volume
- overflow data (including overflow start time, duration, estimated volume)
  - Power and Efficiency
- pump efficiency in gallons or liters per KWHr - or KVAh
  - power in kW, KVA
  - power factor
- energy accumulators per pump in KWHr and KVAH
  - Insulation resistance value for each pump motor in Ohms
  - I/O Status
    - Digital I/O status and accumulated values
    - Analog I/O status with a value in mA and a scaled value
    - 3-phase voltage, frequency, phase angle, power factor
  - Database viewer function to review statistics and tag data information in real time.
  - Communications information and statistics.
- The main screen must include a FAULT button to view fault information as follows:
  - The fault screen will provide fault details along with a date/time stamp.
  - A fault reset option must be presented to the user.
- The main screen must include a HISTORY button to browse history information as follows:
  - View recorded pump station events along with a date/time stamp
  - The history log must be capable of being filtered to display individual events
- The main screen must include a SETTINGS button to configure the pump controller as follows:
  - Set point programming of pump activation values and level alarm values
- Enable/Disable level alarms, faults and historical data recording
  - Configuration of Inputs and Outputs
  - Setup parameters for each type of fault available in the pump controller
  - Set alternation mode for pumps
  - Configure station optimization parameters

- Configure voltage supply monitoring parameters
- Configure motor monitoring parameters
- Configure communications parameters
- Configure data logging parameters
- Enable level simulation session
- Create or restore backup copies of the pump controller configuration settings
- Restart the pump controller

■ The Hardware must have following features:
- The pump controller inputs and outputs must be modular and must be expandable.
- Available I/O types must include:
  - Digital Inputs (discrete, voltage free input)
  - Digital Outputs (dry contact type, rated at 240VAC/DC, 5A resistive)
  - Analog Inputs (10bit)
  - Analog Outputs (10bit)
- Digital Inputs must be configurable based on specific input requirements as follows:

■ Pump sensor inputs: Flygt FLS circuit, Conductive Seal, PTC Thermistor (overtemp)
  - Conductive probe sensing (for liquid level monitoring)
  - 2 High speed counter inputs
- The pump controller must include the following data communication ports:
  - 2 Ethernet ports (10Mbit/s)
  - 2 RS232 ports (115kBit/s)
  - 2 RS485 ports (115kBit/s)
  - 1 USB device port
  - 1 SD card port

■ The pump controller must support the following communication types.
- TCP/IP Ethernet
- UDP
- RS232 Serial Data
- RS485 Serial Data
- Private radio over RS232
- PSTN (Dial-up)
- Wireless LAN
- Cellular Communications

■ It must be able to communicate with following protocols:
- DNP3 (master & slave, level 2 compliant)
- Modbus (master & slave) as follows: Modbus TCP, Modbus RTU, Modbus ASCII

■ The pump station controller must be designed for following environment and performance:
- Central Processing Unit Speed: 566MHz
- Central Processing Unit RAM Size: 256Mbyte
- Central Processing Unit Flash Memory Size: 64Mbyte
- Real Time Clock (with battery backup)
- working temperature: -10°C to +60°C
- Storage temperature: -40°C to +90°C
- Humidity: 5% to 95% (non-condensing)
- IP Ratings: Controller Base Unit (IP20, NEMA 1), Display Keypad (IP65, NEMA4)

4.24.6.4. **Backup control system** (Multitrode, Goulds, or approved equal).

■ The backup control equipment must be supplied with the following specifications:

- The control relay must accept 2 or 3 level inputs from ball floats
- The following settings must be dip switch programmable from the front panel:
    - Conductive probe sensitivity adjustment.
    - Activation Delays.

■ Charge/Discharge selection. (MTR Relay)
    - Level Alarm Output (MTRA and SAFE-TL Relay)

■ Overtemp and Seal Condition Detection (SAFE-TL Relay)
- Mounting and Installation: DIN Rail or 2 x #6 screws Base Mount

■ Output Contact Rating: 250VAC, 5 Amps Resistive, 2 Amps Inductive.

4.24.6.5. **Hazardous Location Protective Device** (Flygt, Allen Bradley, or Approved Equal). The Hazardous Area Protective Device is intended to protect equipment and personnel in areas where hazardous conditions may be present.

■ The intrinsically safe device must be supplied according to the following specifications:
- The intrinsically safe barrier must be panel mounted and designed to protect a multi-sensor conductive probe or ball float inputs.
- The barrier must be certified intrinsically safe for use with equipment in installations up to and including Class 1 Zone O.
- The intrinsically safe barrier must have screw terminals for wire connections.

■ The intrinsically safe barrier must be protected and current limited according to the requirements of UL Class I (Groups A, B, C & D), Class II (Groups E, F, & G) and Class III certification.
- The device must also be CE and CSA listed for applicable locations and must allow a maximum short circuit current of 10 ma.

■ The intrinsically safe barrier must be surface mounted using the mounting flanges on either side of the unit assembly.

■ The unit must be fastened with approved screws or bolts in conformance with UL requirements.

4.24.6.6. **Control Panel Construction and Assembly**.

■ The control panel must be installed on a level which can't be flooded even by storm water.
- The controller must be installed in the Pump Station Controller.

■ The control Panel must be manufactured in accordance with ISO 9000-2001 specifications and must be so constructed for the application of a UL Listing Label by an approved UL Control Panel Assembly Facility.

■ Electrical connections must be properly inspected and torqued in compliance with ISO specifications. External connections to the control panel must be by way of numbered terminal blocks.

■ Control Panels must be properly checked and load tested with power applied. A control panel test log must be supplied with the control panel.

■ Control Panels must be supplied from a UL approved control panel assembly facility with of the required labels properly attached.

■ Control Panel Enclosure Environmental Rating. Control Panel Enclosure rating must be specified in accordance with the project requirements or the Contract drawings as either NEMA 12 (painted steel) or 4x (stainless steel).

■ Control Panel Enclosure Requirements.
- Enclosure must be sized according to physical and functional device requirements.
- Enclosure seams must be continuously welded and ground smooth.
- Enclosure door opening flange trough must exclude liquids and contaminants.
- Enclosure must include an integral body grounding stud and sub-panel mounting studs and be wall mounted, unless otherwise specified.
- Enclosure door must have hidden hinges for a clean, aesthetic appearance.

- Enclosure door opening angle must be standard, full access, 135° opening radius.
- Enclosure door must be interchangeable and removable by pulling a hinge pin.
- Enclosure door must have a high-impact thermoplastic data pocket mounted on the inner side of the enclosure door and must have a seamless, foam-in-place, one-piece gasket to provide an oil-tight, dust-tight seal against contaminants.
- Enclosure must have a three-point latching system with a zinc die-cast handle that is painted with black textured polyester powder paint.
- Enclosure handles must be capable of being padlocked.

- Steel sub-panel must be white.
- When enclosure cut-outs for instruments and other devices are required, holes must be cut, punched, or drilled and finished with rounded edges.
- Instrument Location Requirements
- Instruments or control devices designated for sub-panel (back) mounting must be located in a manner that will allow for maintenance and adjustment.
  - Instrument mounting height must not exceed 6 ft.-6 in. to the top of the instrument and must not be lower than 3 ft.-0 in. to the bottom of the instrument (unless otherwise specified).
- Wiring Requirements:
  - Wiring for AC and DC control circuits must be Type SIS or Type MTW stranded copper and must be sized for the applied voltage and current. Unless otherwise noted, control circuit wiring must not be smaller than No. 16 AWG.
  - Cable wiring for analog signal circuits must be twisted, shielded pairs of stranded copper conductors that must not be smaller than No. 20 AWG.
  - Wiring for special signaling equipment such as communications, digital data, and multiplexed signals must be provided by the equipment supplier.
- Wiring must be numbered and marked at each termination point.
  - Terminal blocks for internal or external wiring must be DIN rail mounted with screw compression type terminals and machine printed labels.
- Nameplate Requirements.
  - Nameplates are defined as inscribed, plastic plates mounted above or near a panel face mounted component. Unless otherwise noted, nameplates must be engraved, rigid, laminated plastic with an adhesive back. Nameplate color must be blue with white letters.
  - Component Labels are defined as printed, vinyl labels mounted above, below or near a sub-panel (back) mounted component for identification. Printed vinyl labels must be white in color with black letters and an adhesive back.
- Grounding:
  - Control Panel enclosure must be properly grounded in conformance with the National Electrical Code and local code requirements.
  - Each analog signal loop must have a shield wire connected to ground at a single point for the loop. Shields must be grounded at control panels where signals are input to the receiving device and not at the source of the transmitting device.
- Electrical Transient (Surge) Protection
  - Electrical and electronic components of the Control Panel must be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and surges in nearby electrical systems.
  - The transient surge protector must be rated for 25kA per phase or larger.
- Circuit Breakers
  - Power Circuit Breakers must be thermal magnetic type designed for AC current with a minimum interrupting capacity of 15,000 amperes.

- Control Circuit Breakers must be in accordance with Section UL 489 with a minimum interrupting capacity of 10,000 amperes.
- Control Power Transformers. Control Power Transformers required to provide control system and accessory power must be machine tool type control transformers with epoxy encapsulated coils or resin impregnated coils, high quality silicon steel laminations, copper magnet wire, molded terminals, and 55°C rise (Class 10 insulation system).
- Supply Voltage/Phase Monitor
  - The voltage-phase monitor must continually measure the voltage of each of the three phases of the incoming power to the equipment and provide protection for three phase motors and sensitive electronics.
  - The phase monitor must sense the following conditions: under- and over-voltage, voltage unbalance, phase loss and phase reversal.
- Control Relays:
  - Control relays must be square base type with coil voltage (120VAC, 12VDC or 24VDC).
  - Control relays must be 4PDT (4 Pole, Double Throw) with normally closed/normally open contacts rated at 120VAC, 5 amps minimum.
  - Control relays must include an integrated test button and relay energized flag indicator.
- Full Voltage Magnetic Motor Controller:
  - The motor controller must be a NEMA rated, full voltage, non-reversing, across the line contactor and overload relay combination.
  - The motor overload relay must be an ambient compensated type with inverse-time-current characteristic and must be provided with heaters or sensors in each phase matched to nameplate full load current of the specific motor to which it connects.
- GFCI Convenience Receptacle: There must be a 120VAC, 15 Amp GFCI rated convenience receptacle mounted on the dead front swing door of the control panel. Receptacle circuit must be protected by a thermal magnetic circuit breaker.
- Enclosure Condensation Heater. There must be a 120VAC, 50-watt enclosure heater inside the control panel. The heater must be a silicone rubber, insulated strip type enclosure heater. The heater must be Chromalox Model #SL-B-2-5-55P or approved equal.
- Local Alarm (Flashing Light): There must be a Flashing Alarm Light mounted on top of the control panel enclosure for local alarm indication. The flashing alarm light must be supplied according to the following specifications:
  - UL Recognized for use with UL NEMA Type 12 Enclosures.
  - Shatter Resistant Lexan globe, U.V. Stabilized and Flame Retardant.
  - The Flashing Alarm Light must be by Ingram Products, equivalent by Phoenix Contacts or approved equal.

4.24.7. **Execution**. Perform installation in accordance with this Item and manufacturer's specifications.

4.24.7.1. **Examination**. A factory trained technician must examine the work area before beginning work and check the following.

- The environment is safe to begin working in,
- All surfaces are ready to receive work,
- All tools are in the proper location and are in good condition, and
- Grounding of the system.

4.24.7.2. **Field Quality Control**. The follow field tests must be performed by a factory trained technician.

- Point to point wiring verification,
- Utility power verification,

- Site acceptance testing, and
- System demonstration.

Point to Point I/O Verification. After installation of the pumps and the control panel, a factory trained technician must prepare the I/O checklist. The checklist must include the following.

- All inputs and outputs connected to the control panel
- All alarms that can be generated by the control panel

The technician must follow a test procedure to test I/O and alarms.

- All digital inputs must be tested from point of origin unless it is unsafe.
- All digital outputs must be tested by running a simulation test from the controller or by simulating the fault condition.
- All analog inputs must be tested from the point of origin where possible and by use of a signal generator otherwise.
- All analog outputs must be tested by running a simulation program or by forcing the output to a value.

The technician must follow a test procedure to ensure the system operation parameters are met.

Configuration Verification. The factory trained technician must document the settings using a factory provided configuration checklist. Each parameter must be verified before the beginning of testing and then again after testing is completed. The configuration of the pump station manager as well as the IPS gateways must be documented. The pump station manager configuration must be saved to a factory provided SD card after testing is completed.

4.24.7.3. **Factory Trained Supervision**. Procure a factory trained technician to check over equipment before putting the equipment into operation. Perform point-to-point testing of the wiring. Perform functional test of the equipment alarms and controls.

4.24.7.4. **Certification of Testing**. Tests must be performed in the presence of a duly authorized representative of the Engineer. If the presence is waived, provide certified results. Written notice of tests must be given 2 weeks in advance.

4.24.7.5. **Test Equipment**. Test equipment must be provided by the Contractor.

4.24.7.6. **Training**. Training must be at least 4 hr. and cover the complete Pumping System and related controls. Instruction material must be provided for at least 4 trainees.

4.25. **I/O List (Refer to Table Below)**.

Table 2
I/O Values

Equipment	Description	Type	Lo Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #1	Pump Controller Fail	DI	N/A	Pump Controller Fail	Primary Modbus Communication
Storm Water Pump #1	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Primary Modbus Communication
Storm Water Pump #1	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Storm Water Pump #1	Speed Indication	AI	4mA	20mA	Primary Modbus Communication
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication

Equipment	Description	Type	Lo Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #1	Pump Running	DI	N/A	Running	Primary Modbus Communication
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #1	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication
Storm Water Pump #1	E-Stop	DI	N/A	Emergency Stopped	Primary Modbus Communication
Storm Water Pump #1	VFD/Bypass	DI	VFD	Bypass	Primary Modbus Communication
Storm Water Pump #1	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water Pump #1	Seal Fail	DI	N/A	Seal Fail	Primary Modbus Communication
Storm Water Pump #1	Overload	DI	N/A	Overload	Primary Modbus Communication
Storm Water Pump #1	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication to SSRV
Storm Water Pump #1	Pump Running	DI	N/A	Running	Primary Modbus Communication to SSRV
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication to SSRV
Storm Water Pump #1	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication to SSRV
Storm Water Pump #1	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication to SSRV
Storm Water Pump #1	Pump Controller Fail	DI	N/A	Pump Controller Fail	Secondary Hardwire Communication
Storm Water Pump #1	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Secondary Hardwire Communication
Storm Water Pump #1	VFD Fault	DI	N/A	VFD Fault	Secondary Hardwire Communication
Storm Water Pump #1	Speed Indication	AI	4mA	20mA	Secondary Hardwire Communication
Storm Water Pump #1	Pump Fail	DI	N/A	Pump Fail	Secondary Hardwire Communication
Storm Water Pump #1	Pump Running	DI	N/A	Running	Secondary Hardwire Communication
Storm Water Pump #1	In-Auto	DI	Pump Not in Auto	Pump In Auto	Secondary Hardwire Communication
Storm Water Pump #1	VFD Fail	DI	N/A	VFD Fail	Secondary Hardwire Communication
Storm Water Pump #1	E-Stop	DI	N/A	Emergency Stopped	Secondary Hardwire Communication
Storm Water Pump #1	VFD/Bypass	DI	VFD	Bypass	Secondary Hardwire Communication
Storm Water Pump #1	High Temp	DI	N/A	Motor High Temperature	Secondary Hardwire Communication
Storm Water Pump #1	Seal Fail	DI	N/A	Seal Fail	Secondary Hardwire Communication

Equipment	Description	Type	Lo Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #1	Overload	DI	N/A	Overload	Secondary Hardwire Communication
Storm Water Pump #1	Out-Of-Service	DI	Available	Out-Of-Service	Secondary Hardwire Communication
PLC	Seal Fail	DO	N/A	Seal Fail	Hardwire
PLC	High Temp	DO	N/A	Motor High Temperature	Hardwire
PLC	Pump Running	DO	N/A	Running	Hardwire
Storm Water Pump #2	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Primary Modbus Communication
Storm Water Pump #2	VFD Fault	DI	N/A	VFD Fault	Primary Modbus Communication
Storm Water Pump #2	Speed Indication	AI	4mA	20mA	Primary Modbus Communication
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication
Storm Water Pump #2	Pump Running	DI	N/A	Running	Primary Modbus Communication
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication
Storm Water Pump #2	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication
Storm Water Pump #2	E-Stop	DI	N/A	Emergency Stopped	Primary Modbus Communication
Storm Water Pump #2	VFD/Bypass	DI	VFD	Bypass	Primary Modbus Communication
Storm Water Pump #2	High Temp	DI	N/A	Motor High Temperature	Primary Modbus Communication
Storm Water Pump #2	Seal Fail	DI	N/A	Seal Fail	Primary Modbus Communication
Storm Water Pump #2	Overload	DI	N/A	Overload	Primary Modbus Communication
Storm Water Pump #2	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Primary Modbus Communication to SSRV
Storm Water Pump #2	Pump Running	DI	N/A	Running	Primary Modbus Communication to SSRV
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Primary Modbus Communication to SSRV
Storm Water Pump #2	VFD Fail	DI	N/A	VFD Fail	Primary Modbus Communication to SSRV
Storm Water Pump #2	Out-Of-Service	DI	Available	Out-Of-Service	Primary Modbus Communication to SSRV
Storm Water Pump #2	High Amps/Over Torque	DI	N/A	High Amps/Over Torque	Secondary Hardwire Communication
Storm Water Pump #2	VFD Fault	DI	N/A	VFD Fault	Secondary Hardwire Communication
Storm Water Pump #2	Speed Indication	AI	4mA	20mA	Secondary Hardwire Communication
Storm Water Pump #2	Pump Fail	DI	N/A	Pump Fail	Secondary Hardwire Communication

Equipment	Description	Type	Lo Value (Disengaged)	High Value (Engaged)	Notes
Storm Water Pump #2	Pump Running	DI	N/A	Running	Secondary Hardwire Communication
Storm Water Pump #2	In-Auto	DI	Pump Not in Auto	Pump In Auto	Secondary Hardwire Communication

4.26. **Systems Integrator and Pump Control System General Requirements**.

4.26.1. **General**. Obtain the services of a subcontractor who will provide a complete integrated Pump Control System (PCS) including but not limited to provision and integration of a new Station Pump control Panel, Sludge Pump Control Panel, Level Control Panel, Local control Panels, Signal duplicators, VFD/SSRVS, building security systems, building air conditioning/heat relief system, security systems, fire alarm system, generator, level control instruments, and existing Remote Terminal Unit (RTU) panels, Generator Auxiliary Control Panel, generator field instrumentation and associated control panels, controls coordination at the Pumping Station and electrical subcontractor, programmable controller system hardware and software, and software programming as shown on the plans and the Specifications.

Plans show general intent and functionality of the control system and is not intended to show required I/O, wiring, etc. The System Supplier is responsible for the design and inclusion of necessary components to ensure a complete and operable system.

The system integrator will provide programming and graphic displays of the new pumping station PLCs, OITs, and the HMI systems, modify the existing RTU. Changes must reflect changes made to the control strategies and monitored signals under this Contract. These modifications must incorporate new devices and equipment, in accordance with the Contract Documents; as well as the integration of new communication links between the PLCs and equipment associated with the new Motor Control Center at the Pumping Station.

SCADA communication. The Contractor must work with the System Integrator and electrical subcontractor to coordinate with TxDOT to relocate and expand the existing RTU to the proposed building. Existing Station operation status and alarms communication to SCADA must remain online for the duration of the project. Detailed outage requests must be coordinated with and submitted for approval.

This subcontractor will hereafter be referred to as the System Integrator (SI). The SI will have total responsibility for the design, programming, testing, start-up and implementation of the Pump Control Systems, and associated control, status and alarm functions for Facility.

As referenced above, the SI is responsible for performance and coordination of the PLCs and Control Systems associated with the existing SCADA system and RTU.

Ensure the SI is available for coordination with other equipment suppliers and the existing SCADA radio network for implementation of the required functions of the equipment in the Pump Control Systems.

- The Systems Integrator will provide necessary junction boxes, panels, transformers, power supplies, relays, terminal blocks, fusing, grounding, and other components required to meet manufacturers' requirements and to produce complete and fully functioning systems.
- It is a requirement of these Specifications that the Systems Integrator be responsible for purchasing pump control equipment consisting of, but not limited to, the following: motor control center, PLC equipment including expansion and modifications of any existing PLC cabinet, SCADA equipment, computer software, and field instruments.
- Exception. Subject to the approval of the Engineer, the Contractor or subcontractor other than the Systems Integrator may be permitted to furnish pump control items requiring complete system integration. The decision to deny or to permit pump control items to be furnished by parties other than

the Systems Integrator will be final, and the Contractor will not be entitled to any claims based upon the decision rendered.

- Complete Pump Control Systems integration remains the responsibility of the Systems Integrator regardless of whether the Systems Integrator furnished the pump control equipment or another party was permitted to furnish some portion of the pump control equipment.
- The Systems Integrator is responsible for fully understanding operating conditions, limitations, and criteria of existing motors to remain and new motors to be provided under this Contract regardless of whether the motors are being furnished by other parties or are being furnished by the Systems Integrator. Furthermore, the Systems Integrator will be responsible for fully integrating motor operations required to provide a fully functioning Pump Control Systems. Motor operations requiring complete integration include, but are not limited to,
  - Normal starting (VFD Operation, across-the-line starting, etc.);
  - Emergency starting, as applicable;
  - Running;
  - Normal shutdown;
  - Backup Control Operation;
  - Communications Failure;
  - Emergency shutdown; and
  - Alarming and report-back.
- As applicable to the Contract, the following components of the pump motors and the motor control center must be fully integrated into the design provided by the Systems Integrator.
  - VFD's,
  - MCC's,
  - Reduced voltage soft starters,
  - Run contactors,
  - Bypass contactors,
  - Power factor correction capacitors,
  - PLC's,
  - Uninterruptable power supplies,
  - Surge protection devices,
  - Other protective devices, and
  - Timers and relays.
- Switches, push buttons, and indicating lights
- SCADA, monitoring devices, and recording devices
- In addition to the main pumping units, other motor-driven devices that require complete integration to be provided by the Systems Integrator include:
  - Air Conditioning/Heat Relief System
  - Security System
  - Fire Protection
  - Generator System/ATS
- Field equipment requiring complete integration by the Systems Integrator includes, but is not limited to: level transmitters, pressure transmitters, limit switches, flow switches, flow meters, differential pressure transmitters, solenoid valves, HVAC controls (thermostats, humidistats, etc.), control systems enclosures, temperature switches, intrusion switches, light switches, beacons, control panels UPS's, ATS, power monitor, MCC, and battery chargers.
- Certain field equipment require integration by the Systems Integrator into multiple systems. The Systems Integrator is responsible for fully integrating field equipment into appropriate systems as required by this Contract.

4.26.2. **Quality Assurance**. Regulations, Standards and Publications.

- UL Underwriters' Laboratories, Inc.
- NEC National Electrical Code
- NEMA: National Electrical Manufacturers Association
- ANSI: American National Standards Institute
- IEEE: Institute of Electrical and Electronic Engineers
- ISA: Instrument Society of America

Quality Control.

- Provide new components of the Pump Control Systems of the most current and proven design. Furnish components suitable for the intended application and installed and wired in strict accordance with the manufacturer's requirements and this Specification. The System Supplier must provide necessary junction boxes, panels, transformers, power supplies, relays, terminal blocks, fusing, grounding, and other components required to meet the manufacturer's requirements and produce a complete and functional system.
- The complete system must comply with Federal, State, Municipal, or other authority's laws, rules, or regulations.
- MCCs and control panels, and their components and materials, must bear the label of the Underwriters' Laboratory. Control panels must be UL listed as a complete assembly.

4.26.3. **Submittals**.

- Components required to function as a unit must be submitted as a single item; separate submittals of individual components will not be accepted and will be returned to the Contractor as "Rejected" without further review.
- New items requiring complete integration which are not being furnished by the Systems Integrator, nevertheless, require review and approval from the Systems Integrator.
- In addition to bearing the appropriate General Contractor and subcontractor submittal cover sheet, submittals for such new items must include a statement, signed and dated by the Systems Integrator, as follows:
  - "Items (or item) included in this submittal are being furnished by parties other than the Systems Integrator. These items have been thoroughly reviewed by the Systems Integrator and have been determined to be in full compliance with the requirements of the Contract. Furthermore, the Systems Integrator has determined the items included in this submittal are fully compatible with other items requiring systems integration including both existing-to-remain items and new items to be provided under this Contract."
- Shop Drawings:
  - Submit required number of detailed shop drawings for equipment being provided for the Pump Control Systems. Shop drawings must be submitted within 90 days of the date of Notice to Proceed, but only after the required pre-submittal workshop has been conducted.
  - Shop drawings should be submitted in accordance with Item 5, as described in the General Notes, and should be complete, neat, orderly, and indexed. Separate shop drawing submittals must be made for each major system component.
  - Refer to individual Specification sections for specific shop drawing requirements.
- The SI must submit a complete set of engineered drawings for the Local Control Panel, and Programmable Controller system hardware. These engineered drawings must be done by the System Supplier using Autocad. The drawing size should be 11 in. × 17 in. as requested. Drawings include, but not be limited to, the following.

- Control panel elevation, details, front and back panel layout, and wiring diagrams showing terminal numbers and interconnecting wiring. The control panel layout drawings must include dimensions for the location of panel-mounted devices.
- Programmable controller system block diagram, power wiring diagrams and I/O wiring diagrams showing terminal numbers and interconnecting wiring.

- Color copies of screens developed for the Operator Interface Terminals along with a flow chart indicating how each screen is accessed.
- Calculations for the Uninterruptible Power Supply.
- Plan to integrate the new I/Os into the existing RTU and existing SCADA communication Drawings must be easily readable with minimum 1/8 in. text height.
- Prepare and submit comprehensive wiring diagrams for the instrumentation work performed under this section. Drawings must include the following:
  - Control wiring diagrams and ISA standard loop drawings with terminal numbers and control devices identified. Loop drawings, one per sheet. Provide 8-1/2 in. by 11 in.) or 11 in. by 14 in. Drawings must show sizes and locations of equipment and their control locations. Include detailed dimensions of unit locations, elevations, details, door-mounted devices, and front and back panel layout. Include detailed dimensions of conduits, pull boxes, and wiring troughs.
  - Wiring diagrams must contain internal and external ladder wiring schematics with identified terminal numbers, relays, and other control devices. Control electrical diagrams must be drawn with circuitry arranged in functional sequence on ladder-type diagrams. Each horizontal line on the ladder diagram will be assigned a number must be written to the left or right of the ladder. Draw relay coils on the right side of the ladder. Show the line numbers on which the relay contacts appear be shown on the right of each coil. A normally closed contact should be designated by drawing a diagonal line through the contact. Designate timed contacts by the letter "T" under the line number. Prepare instrument logic diagrams and schematics using ISA 55.1, IEEE 315 and 315A, and NEMA standard symbols and identification letters.
- Submit drawings in a timely manner to allow for engineering review and incorporation of additions or modifications.
  - Provide a list of parts including numbers and quantities.
- Furnish final as-built drawings on diskettes compatible with AutoCAD formats.
- Control panels furnished by the Contractor must include panel layout drawings and associated wiring schematics as defined above.
  - Integrator’s Data and Drawings. The Control Systems Integrator must submit at least 7 complete sets of the following information for the Engineer's approval:
    - Point-to-point wiring drawings
    - Process loop drawings
    - Dimensional drawings, wiring or piping drawings for field and pipeline-mounted equipment
    - Equipment Specification sheets
    - For control panels: fabrication and nameplate legend drawings and internal wiring schematic drawings
    - Systems schematic drawings illustrating components being supplied complete with electrical interconnections
    - Dimensional drawings, wiring or piping drawings for field and pipeline-mounted equipment
    - Equipment Specification sheets
    - For control panels: fabrication and nameplate legend drawings and internal wiring schematic drawings

- Systems schematic drawings illustrating components being supplied complete with electrical interconnection.
- Computer input/output lists and a written description of the control strategy to be applied to the various process areas
- For process computer systems: system block diagram and control room layout drawings

- After approval, furnish seven complete bound sets of the above information plus the following:
  - Individual Operating and Maintenance Manuals
- Bulletins for each piece of equipment furnished
  - Complete spare parts list for each piece of equipment
  - Calibration sheets
- A minimum of 8 weeks before factory testing, the Systems Integrator is required to submit color copies of proposed Human-Machine Interface (HMI) screens along with a flow chart indicating how each screen is accessed to the Engineer for approval.
- Installation, Operation and Maintenance Manuals:
- Submit installation, operation and maintenance manuals in 3-ring loose- leaf binder. Manuals must be complete, neat, orderly, and indexed. Submit information in accordance with Article 3. Unless directed otherwise, include the following elements in the preliminary and final O&M manuals:
  - Erection and installation sequence and instructions;
  - Exploded view drawings and illustrations with sequence description for assembly and disassembly of equipment;
- Comprehensive parts and materials list for each equipment element indicating manufacturer and manufacturer's identification number; include name, address, and telephone numbers of sales and service offices nearest project site for each major equipment item;
  - Schedules of recommended spare parts to be stocked, including part number, inventory quantity, and ordering information;
- Performance rating and nameplate data for each major system component;
- Procedures for starting, operating, adjusting, calibrating, testing, and shutting down system equipment;
- Emergency operating instructions and troubleshooting guide;
- Schedule of routine maintenance requirements and procedures, and preventative maintenance instructions required to ensure satisfactory performance and equipment longevity;
  - Maintenance instructions for extended out-of-service periods;
  - Complete listing of software programming and licensing agreements;
- Complete operator's Supervisor's Manual for the Control System which includes system hardware and software and the “how to's” of the system;
- Test reports;
- ISA specification sheets filled out to reflect final field instrument calibration, purchased model number, and any other as-built condition;
  - As-built shop drawings of panels, wiring, instruments, etc.; and
  - All standard O&M manuals for equipment.

4.26.4. **Coordination**.

- The SI will conduct an initial pre-submittal workshop and coordination meeting with the Contractor and Engineer to review the scope of the project and the project schedule and discuss the Department’s preferences for how the system will be designed to operate.
- A submittal progress meeting will be conducted by the SI at the 50% complete stage with the Contractor and Department personnel to discuss progress of the design and questions that may arise.
- Approximately 30 days after the 100% complete submittal is made, the SI will conduct a final submittal review meeting with the Contractor and Engineer to discuss final comments before system fabrication.

- The SI is responsible for coordinating the compatibility of components and equipment with the Contractor, particularly the pump motors and associated components.
- The Systems Integrator is responsible for coordinating the compatibility of components and equipment used in control systems of this Contract.
- New work: Should the Systems Integrator determine that there is some incompatibility regarding two or more components to be provided under this Contract, they must bring this issue to the Engineer's before the 50% complete submittal stage. The Engineer will make a decision regarding systems integration; the decision will be final.
- Rehabilitation work: For rehabilitation work utilizing existing components to remain, the Systems Integrator is required to develop an understanding of those existing components to the fullest extent practicable and incorporate that understanding into the integration of new and existing components. In the event the Systems Integrator determines there is some incompatibility between on 1 or more existing components to remain and one or more new components to be provided under this Contract, they must bring this issue to the Engineer's attention before recommissioning existing components and before the 50% complete submittal stage for new components. The Engineer will make a decision regarding systems integration; the decision will be final.
- In order to ensure compatibility between instrumentation components and equipment, it is the responsibility of the Systems Integrator to coordinate interface requirements with the existing mechanical and electrical hardware and to furnish and install signal isolation devices as required to provide safe, reliable, and fully functioning control systems.
- The Systems Integrator and the Contractor must investigate each space in the building through which equipment must pass to reach its final location. If necessary, the Systems Integrator is required to ship the components in sections, sized to permit passage through such areas. The Systems Integrator and the Contractor also must investigate space and allocated access (front, rear, side); any subsequent concerns must be brought immediately to the attention of the Engineer.
- The Systems Integrator must coordinate the installation, placing, and location of system components, their connections to the process components, panels, cabinets, and devices as required to complete the work subject to the Engineer's approval.
- As this is an operating pumping station, the pumping facilities must be fully operational at all times. work must be coordinated with the Department's personnel.

4.26.5. **Factory Acceptance Test**.

- The SI will conduct a factory acceptance test for the Pump Control Systems before shipping the equipment. The factory test will be conducted at the supplier's facility and will demonstrate the control system was designed and performs in conformance with the Specifications and plans. Equipment furnished for the Pump Control Systems must be assembled and interwired so that it functions as a complete system for the factory acceptance test.
- The SI must provide necessary equipment and hardware required to conduct the factory test.
- The factory acceptance test must demonstrate the proper operation of control logic in conformance with the Specifications and plans, and system hardware and software. The factory test will be witnessed. Testing must occur within the 48 contiguous states. If testing is not within 2 hours of the project site, the SI is responsible for the travel expenses of up to two Department representatives to witness the test. Coordinate scheduled dates with required parties.
- A detailed step-by-step test procedure for testing activities is to be delivered to Engineer not less than 60 calendar days before the scheduled start date. Engineer reserves the right to reschedule the start of the test if a proper, approved, complete test procedure is not available at least six weeks in advance of the scheduled test date.
- Confirm in writing, times and dates two weeks before a test.

- Perform a walkthrough of equipment supplied. Utilize checklist provided as part of the test procedure documents to verify presence of required components. Note any exceptions. Engineer reserves the right to cancel remaining test activities if items are missing.
- Inspect each enclosure. Demonstrate quality of workmanship, labeling, dressing of cables, conformance of enclosures with plans. Record comments on test procedure documents.
- Demonstrate basic PLC functions for each PLC including, but not limited to the following:
- The System Integrator must utilize the new PLC controller in conjunction with the PLC cards, modules, backplanes, signal duplicators, and Ethernet switches specified by the Contract Documents to allow for factory testing of the new PLC programing and simulation of the interaction and communication between the individual system components and the Pump Control panel. Any additional temporary or special equipment, relays, etc. needed to fully test the system must be provided by the SI. Following testing the spare equipment must be repackaged for long term storage and turned over to the Department.
- Exercise every I/O point served by the Pump Control Panel PLC modified under this Contract. Include spares. Provide necessary simulation equipment to simulate discrete inputs, discrete outputs, analog inputs, analog outputs, and serial communication. Simulation equipment should be provided with multiple channels to enable testing of several I/O points without need to connect or disconnect for each point.
- Test each analog input at 0, 50%, 100% of full scale by creating proper signal (e.g., 4-20 mA or 1-5 Volts) using signal sourcing device.
- Provide an appropriate load (light or buzzer) to test each discrete output. LEDs on DO cards are not enough as an indication of proper DO function.
- Provide suitable meter to measure each analog output point at 0, 50 and 100% of full scale. Provide appropriate switches to simulate contact closures to test every digital input point.
    - Demonstrate UPS operation for brief power outage.
- Provide the following documentation:
    - One copy of submittals applicable to the equipment to be tested.
    - One copy of the plans and Specifications together with addenda and change orders.
    - One master copy of the test procedure.
    - A complete inventory of the equipment to be tested including make, model and serial number.
- Provide use of the following test equipment:
    - Input/Output Test Set: This set must be wired to representative input and output components to allow complete testing of these components.
    - Off-line diagnostic and test programs.
- Maintenance and test equipment including, but not limited to voltmeter, ammeter, ohmmeter, oscilloscope, electrician's tool set, and special test equipment.

4.26.6. **Record Drawings**.

- Submit required number of record or as-built drawings for the Pump Control Systems before the delivery of any equipment to the site. Provide an as-built drawing in the control panel.
- Following start-up and commissioning of the system, the SI will make necessary changes to the as-built drawings and re-submit required number of final as-built drawings. A final as-built drawing must also be provided in the control panel.

4.26.7. **System Installation, Start-Up, and Commissioning**.

- System Installation:
- All field wiring to the equipment furnished by the SI must be performed under the electrical requirements of the Contract by the Electrical Contractor under the supervision of the Pump Control Systems Supplier.

- The SI will provide onsite supervision and advice to the installing Electrical Contractor to ensure the system is installed in conformance with the specifications and the manufacturer's requirements.
  - Field wiring may be performed by the Systems Integrator directly or may be performed by the electrical subcontractor working under direct supervision of the Systems Integrator.
- The Systems Integrator must provide onsite supervision and advice to the installing electrical sub-contractor to ensure that control systems are installed in conformance with the Specifications and the manufacturers' requirements.
- For the following connections, the Systems Integrator is responsible for ensuring that field wiring for power and signal circuits are done correctly in conformance with best industry practices to ensure satisfactory functioning installations:
  - Between individual existing devices;
  - Between existing devices and proposed control systems;
  - Between multiple proposed control systems; and
  - Within individual proposed control systems
- The Systems Integrator is responsible for ensuring that control systems are installed properly, tested, and fully operational.
- All proposed instrumentation and control systems must be installed, tested, and operating properly before existing systems are taken out of service.
- System Start-Up:
- Submit a detailed testing and start-up plan two weeks before start-up for approval and coordinate scheduled dates with required parties. Submit open and closed loop signal test sheets listing possible signals to be tested for review and approval.
- Conduct open loop point to point wire testing in conformance with the approved signal test sheets in the presence of the Engineer. Install conduit and wiring before to open-loop testing.
- Conduct closed-loop testing from field devices to PLC in conformance with the approved closed-loop test sheets in the presence of the Engineer. The open and closed loop testing must be on separate days.
  - Start-up the control system by energizing the system equipment and testing the operation of hardware, software, process control logic, and customized software programs.
  - All start-up and testing must be scheduled, performed in an orderly sequence, and conducted in the presence of and to the satisfaction of the Engineer.
  - Include the following information in the submittals for this section:
    - Loop checkout schedule.
    - Loop checkout procedure including sign-off forms.
- Schedules, procedures, and sign-off forms for other tests specified.
- Supply two-way radios and cellular telephones for use during the field test activities to permit two-way communications by personnel between sites. These phones and radios will be used by the Engineer and the Contractor, as necessary.
- Perform field testing to verify the operation of the Pump Station controls. Field tests are as follows:
  - Loop tests after troubleshooting.
  - Function tests.
  - Integrated system test.
  - Testing will begin after installation of the system components at the site. These must include:
    - PLC's.
    - Instrumentation.
    - Communications equipment required for operation of the system.
    - Other field instruments, panels, switches, termination cabinets, control devices and related interconnections.

Begin testing by performing the following steps:

- Check equipment against shop drawing list.
- Verify that the equipment has been installed in accordance with Contract Documents and manufacturer's directions.
  - Power up the equipment and calibrate power supplies.
  - Load applications software.
  - Run diagnostics to verify error-free operation.
  - Check each signal wire and spares from the field element termination point to the PLC I/O terminal block. Verify end to end continuity of each wire, and that no stray voltage exists on any other wires. Verify that voltage drop through the wire from end to end is within acceptable limits, as specified. Note and correct any deficiencies.
- Verify that each wire label shows proper wire identification, is legible and that the wire designation shown on the loop drawing matches exactly the wire designation shown on the wire label. Wires must be identified at each end, including any intermediate junction points. Note and correct deficiencies.
  - Provide space on the loop drawings and test sheets to hold Engineer and Contractor's signatures and dates for this test.
- Check each loop from the end element to the respective control display. Include instruments, control devices, panels, termination cabinets, input/output cards and other devices in the loop to ensure proper operation and linkage to appropriate HMI displays at station.
- Whenever possible, motion check the final control element through panels and through operator control stations. When not possible to perform a motion check, simulate the motion check at the final control element location.
- Document loop checks and submit to the Engineer. Include the following:
  - Loop number.
  - Loop description.
  - Termination information.
  - Loop drawing reference.
  - Type of tests performed.
  - Date tested.
  - Signature of tester and date.
  - Signature of Engineer and date.
  - Problem description, if any.
- Summarize loops found to contain defective or inoperable equipment on separate sheets and submit to the Engineer.
  - Correct and recheck work performed under this Contract.
- The Engineer will coordinate correction of defective work by others, (e.g., other Contractors not involved in this project) and correction of deficiencies discovered in existing wiring or instrumentation. Perform rechecking as a part of this Contract.
  - Test function of the system.
    - Include a demonstration of the following maintenance and support functions:
      - System status displays and use.
      - Diagnostics.
      - Power fail/restart.
      - PLC alarming under loss of communications, loss of I/O, etc.
- Operation of PLC on UPS backup power without AC power connected. Verify that battery has enough capacity to maintain operation of equipment for minimum period specified.
  - Test control functionality, assuring that control schemes and backup schemes work according to descriptions found elsewhere in the Contract Documents
- Document and submit tests to the Engineer. Include the following:

- Description of function;
- Test performed;
- Copies of messages, displays, reports, and trends which verify operation;
- Signature of tester and date;
- Signature of Engineer and date; and
- Problem description, if any.

- Schedule any field testing that may affect the station operation through the Engineer on a daily basis.
  - The SI will not perform any testing which may affect TxDOT and station operations without the Engineer's concurrence.
  - Meet the following conditions before the start of any testing:
    - Correct deficiencies noted during in-factory testing and inspections following installation.
    - Keep onsite documentation pertinent to the equipment being tested.
- Keep onsite, labeled, and properly stored, spare parts, expendables and test equipment pertinent to the equipment being tested.
  - Keep operational field equipment supplied and pertinent to the equipment being tested.
  - Submit Engineer reviewed test schedules and test procedures.
- Re-load PLC'S and OIT's using images supplied by Contractor or Engineer as appropriate.
  - Installation work is complete and approved.
  - Drawings and Operation and Maintenance manuals are available for review.
- Test procedures and test results will reflect information contained within the various operation and maintenance manuals furnished. Perform no test without the appropriate manuals being followed word-for-word unless approved. Lack of acceptable manuals will be cause for declaring the test to have failed regardless of the actual test results.
- The Engineer will determine the site sequence in which testing will be performed.
- System Commissioning: Supervise the factory representative's calibration for instrumentation and place the complete control system into operation. The commissioning of the system must include the overall calibration and tuning of control loops and sequences to provide stable control of the pumps. The validity of inputs and outputs for the system must be checked and corrected during the system commissioning.
- The SI will provide someone onsite for the length of time necessary for system installation, start-up, and commissioning.

4.26.8. **Final Acceptance Test**.

- Following the commissioning of the Pump Control Systems, and the issuance of the Certificate of Substantial Completion to the Contractor, conduct a final acceptance test for a period of 30 consecutive days. This test must be scheduled with the Engineer and will not begin until the SI receives written approval to start. During that time period, the system must operate satisfactorily and in compliance with the Specifications. The SI will promptly correct any problems that occur during the final acceptance test and perform retests as necessary to verify proper operation.
- Following the successful completion of the final acceptance test, a certificate of final acceptance will be issued to the System Supplier.

4.26.9. **Expansion of System I/O**. The System Supplier must include in their cost for this Contract the modification of an additional 25 system I/O points above and beyond those identified or required for completion of Contract work. This must include costs to configure these points within the system including software programming, drawing changes, and field verification.

4.26.10. **Graphics**. The Systems supplier is responsible for developing graphics for each controlled, monitored, or integrated system to match the look and feel of the existing SCADA graphics. The Systems Integrator must provide color sample graphics for each system to be reviewed and approved.

The graphic screens must be configured in a hierarchical format to facilitate the Operator's interface to the process. The hierarchy must consist of a series of graphic screens that provide progressively more detail as the operator navigates through them. Provide a home icon to allow an operator to return to the facility overview display as described herein from any graphic screens. Graphic screens to include but not be limited to Facility Overview display, main displays, secondary displays, data displays, object displays, trend displays, and alarm displays. At a minimum the Contractor must include the programming and creation of 25 graphical screens associated with the facility.

4.26.11. **Additional Software Configuration and Programming**.

- The System Supplier must include in his cost for this Contract four additional man-days of onsite time for software configuration and programming. The service dates will be determined in one day increments and may not be consecutive. This time will be used for changes or additions that may be required after the commissioning of the system. The Supplier's cost for these additional man-days must include software documentation changes and travel related expenses.
- Copies of software licensing and programming requirements must be provided to the OWNER in digital format and printed format also.

4.26.12. **Training**.

- During the final acceptance test, the System Supplier must arrange for the instruction and training of TxDOT personnel in the operational procedures of the system. At the end of the training, operations personnel must have, as determined, enough knowledge to operate the system.

4.27. **Structural**.

4.27.1. **Concrete**. Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." For concrete in slabs, use Class A with Grade 3 aggregate. Place the proposed generator in the required area adjacent of expansion to pump station location, constructing a foundation slab of concrete with rebars.

- Ensure the detailing of concrete reinforcement bars and accessories conforms to the recommendations of the ACI Detailing Manual (ACI 315-80).
- Mix, transport, and place concrete in accordance with ACI 301-84 and Items 420, "Concrete Structures," and 421, "Hydraulic Cement Concrete."
- Provide standard bar chairs and spacers as required to maintain the concrete cover protection specified during rehab procedure.
- Provide 1- No. 4 reinforcement bar x 4.0 ft. at re-entrant corners and around rectangular holes in slabs unless noted otherwise. Place the bars diagonal to the corner with 1 in. clearance from the top and the side of the slab at the corner.
- Provide concrete cover protection for reinforcement bars as follows (see ACI 318 83 Section 7.7 for conditions not noted):
  - Slabs on Grade (Bottom): 3 in.
  - Slabs on Grade (Top): 3/4 in.
  - Pilaster and Plinths: 2 in.
  - Grade Beams (Top): 1-1/2 in.
  - Grade Beams (Side Board Formed): 2 in.
  - Grade Beams (Side Earth Formed): 3 in.
  - Grade Beams (Bottom): 3 in.
  - Footings: 3 in.

4.27.2. **Foundation**. Provide a subgrade under slabs that has a maximum Plasticity Index of 20 and compact in accordance with Section 132.3.D.1., "Ordinary Compaction" of the Item 132, "Embankment." A 2 to 4 in. compacted bank sand layer may be used as a level-up for the slab.

4.27.3. **Structural Steel for Wet Well**. Provide structural steel, rolled shapes and plates conforming to AASTM A 36. Ensure structural steel is hot-dipped galvanized, which are to be painted. Provide stainless steel expansion anchors that have a 4:1 safety factor with a minimum working capacity as follows:

Table 3
Expansion Anchor Requirements

Bolt Diameter (in.)	Min. Shear Strength (lb.)	Min. Pull Out Strength (in.)	Min Embedment (in.)
1/2	2080	1380	2 1/4
5/8	2975	1830	2 7/8
3/4	4280	2530	3 3/4
1	6700	4000	4 1/2

Install the expansion anchors in conformance with the manufacturer's recommendations.

Submit a list of material and specifications (AISI, ASTM, etc.) for the anchor components, as well as pull out and shear values attained from tests performed in accordance with ASTM E488 by a certified independent testing laboratory. Include the manufacturer's installation instructions in the submittal.

Detail, fabricate, and erect the structural steel in accordance with AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings," latest edition and amendments, and the AISC "Code of Standard Practice for Steel Buildings and Bridges."

Do not splice structural steel members if not detailed on the plans without the prior approval of the Engineer as to location, type of splice, and connection to be made.

4.27.4. **Wet Well Roof Access Doors**. Provide floor style access doors. Fabricate the frame from 1/4-in. thick extruded aluminum incorporating a continuous concrete anchor. Fabricate the door leaf from 1/4 in. aluminum diamond tread plate, reinforced with aluminum stiffeners designed to withstand a live load of 300 lbs. per sq. ft. Provide a door capable of opening to 90° and locking automatically in that position with a stainless-steel hold open arm. Incorporate an enclosed stainless steel compression spring assist into the hold open arm. Provide a stainless-steel slam lock with a removable handle for securing the door. Provide a vinyl grip handle to release the cover for closing. Provide an aluminum mill finish, with a bituminous coating applied to exterior of the frame where it will meet concrete. Supply a stainless-steel lifting handle, hinges, and fastening hardware. Install as shown on the plans. Warranty the doors against defects in material and workmanship for a period of 10 yr. and supply a copy of the warranty to the Department.

4.27.5. **Construction Dewatering**. Any dewatering required during any phase of construction is the responsibility of the Contractor. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this Specification for construction dewatering.

4.27.6. **Roof Deck**. Construct the roof deck of 3 plies of tar saturated felt and gravel over 1-in. rigid insultation board screwed to galvanized Type F roof deck. For the Type F deck, use 20 gage cold formed steel conforming to ASTM A 446, Grade A, coating designation G60. Provide a metal deck 1-1/2 in. deep with a minimum section modulus (SP) of 0.139 in. cubed per food of width.

4.27.7. **Masonry**. Use masonry units (CMU) that are hollow concrete units conforming to the requirements of UBC Standard 24-4, and ASTM C90, Grade N, Type 1 with lightweight aggregates in accordance with ASTM C331. Provide masonry units with a split face design in a white limestone color. The minimum allowable compressive strength for masonry units is 2,500 psi at 28 days. Do not install masonry units before they attain the required 28-day strength.

Provide continuous reinforcing bars in bond beams as indicated on the plans. Lap the reinforcement placed in the bond beams at least 36 bar diameters at splices. Provide corner bars of equivalent size lapped 36 bar diameters at corners and intersections of walls.

Field cut the vertical masonry reinforcement for 4 ft. lifts and lap splice at least 30 bar diameters. Grout masonry cores containing vertical reinforcement solid with Class A concrete, Grade 6 aggregate. Perform grouting by the "low lift" method in conformance with UBC Section 2404(f)1. Provide one No. 5 vertical bar at each end, corner, and intersection of walls. At masonry lintels bearing on masonry walls, provide at least 16 in. of bearing over two grouted cores each side of the opening. Reinforce each core with one No. 5 vertical bar. Extend the reinforcement the entire height of the wall. To accomplish this, bar splices lapped at least 24 in. are acceptable.

4.27.8. **work Bench**. Provide a work bench made of heavy steel construction, approximately 36 in. wide by 24 in. deep by 35 in. high with adjustable intermediate shelves and doors. Locate the work bench cabinet in the generator building in a place designated.

4.27.9. **Louvers, Doors, and Burglar Bars**. Provide extruded aluminum louvers placed in the wall of the controls building as shown on the plans. Ensure the backdraft type louver for the generator fan discharge is held closed by springs but can open under air pressure from the fan. Provide hollow metal hinged doors with three medium duty stainless steel hinges for each door and industrial quality self-closers with a hold-open feature, knobs, door holders, and a heavy-duty hasp for a padlock on exterior doors. Provide exterior doors that are 18 ga. Minimum and interior doors when specified that are 20 ga. minimum. Fabricate burglar bars from mild steel and before installing, paint them same color as louvers.

Size the steel roll-up door as shown on the plans and design it for a minimum 20 psf wind load. Ensure its chain operated with a slide bolt interior lock with a provision for a padlock; has galvanized interlocking slats with a two-coat backed-on primer applied before roll forming; and has slats with galvanized malleable iron or steel end locks and wind locks to prevent slat wear at contact to the guides. Grease-pack the spring-counterbalance assembly. Galvanized and prime the steel hood of the spring counterbalance assembly. Provide guides made of structural steel, 3/16 in. minimum thickness and prime painted. Reinforce the bottom of the door with steel angles and a single contact neoprene floor seal.

4.27.10. **Paint**. Paint the doors, fixtures, supports, joists, ceiling, trim, and any other accessories as directed, in accordance with Item 446, "Cleaning and Painting Steel," except give metal a 3.0 mil dry film thickness (DFT) prime coat of red oxide industrial primer with a 2 coat, 2.0 mil DFT each finish coach of industrial alkyd enamel in a color to match the louvers. Pre-paint the extruded aluminum louvers with a "Duranar" fluoropolymer coating (color D=code UC-51515/ Medium Bronze). Paint the interior deck and bar joists to match the walls. Paint the generator set, base, day tank, and motor mounts per generator set manufacturer's standard color.

4.28. **Facility Start-Up and Demonstration Period**. When specified in individual sections of these Specifications, upon completion of work for a particular section, the Contractor must furnish at no extra cost to the Department, the necessary manufacturer's engineers, representatives, technicians, skilled labor, and helpers and must perform start-up activities as required. During start-up, the manufacturer's designated personnel is responsible for fully inspecting, testing, calibrating, lubricating, operating, and certifying the equipment for which they are responsible.

When a manufacturer's representative is not required to perform start-up activities for a particular piece of equipment, the Contractor must perform any required start-up activities in strict conformance with the manufacturer's instructions.

If the Operation and Maintenance Manuals specified hereinafter are not available at the time of the start-up, the Contractor must provide one copy of the manufacturer's operating literature for each system or item of equipment. Installation and operating sheets or booklets normally shipped with equipment may be used for this purpose.

Before starting up and operating equipment installed in the pumping station, notify the Engineer. Perform lubrication and start-up of the equipment in the presence of and to the complete satisfaction of authorized representatives of the Department, and in conformance with manufacturer's recommendations.

Schedule start-up and factory testing activities for a time mutually agreeable with the Engineer and Department and provide at least 1 week notice before the desired date. Complete preparatory work before arrival of the Engineer. Start-up and testing schedule must include the times Department personnel are requested to be onsite. Testing may be canceled and rescheduled in the event the Contractor or any of the Contractors representatives are not prepared to start at the time mutually agreed to start time. The Contractor will not be due any additional time or compensation should testing need to be rescheduled. Contractor will be charged for the time lost by testing cancelations and rescheduling and the cost incurred by the Department, which will be deducted from the Contractor's monthly invoices or from monies retained under the provisions of the Contract Documents.

After start-up activities have been completed, coordinate with the Engineer the start of the demonstrational basis for a period of 30 days.

Before beginning the 30-day demonstration period, the Contractor must complete the following.

- Shop drawings have been submitted and approved,
- Equipment Warranty and Certification Forms and manufacturer's certifications must be completed and submitted, and witness testing conducted and completed as required,
- Start-up activities must be completed,
- Test reports submitted and approved,
- Project photographs must be submitted, and
- Operation and Maintenance Manuals must be submitted and approved.

A final walk-through of the facility will be conducted by the Contractor with the Engineer to generate the punchlist for the project. Provide the Engineer 4 weeks' notice before the desired date.

Any items on the punchlist that are designated as requiring completion before the 30-day demonstration period must be completed.

Any item on the punchlist not designated as requiring completion before the 30-day demonstration period must be completed before the end of the 30-day demonstration period.

All spare parts must be delivered to the Engineer and signed receipts submitted for record.

All SCADA communications between the station and the overall SCADA network must be installed and fully operational.

The facility must be thoroughly cleaned, and any finishes requiring touchup must be completed.

After the above Items have been successfully completed, the Contractor will receive notice from the Engineer that they may begin the 30-day demonstration period.

During the 30-day demonstration period, the Contractor must conduct required training for the newly installed equipment. Training activities must be performed separately from manufacturer's start-up activities and must be held on separate days unless approved otherwise. Coordinate schedule of training with Engineer. Provide at least 2 weeks' notice for each session.

If problems occur during the 30-day demonstration period that are designated to be of significant magnitude, the problems must be satisfactorily corrected, and the 30-day demonstration period will restart from the beginning.

After successful completion of the 30-day demonstration period, required training, punchlist work, and final cleanup, the Contractor will schedule a follow up walk- through with the Engineer to verify compliance with requirements.

5. PRODUCT SUBSTITUTION PROCEDURES

Options for making product or process selections. Procedures for proposing equivalent products or processes, including pre-approved, pre-qualified, and approved products or processes.

5.1. **Definitions**. Product: Product does not include machinery and equipment used for production, fabrication, conveying, and erection of the work. Products may also include existing materials or components designated for reuse.

5.2. **Process**. Any proprietary system or method for installing system components resulting in an integral, functioning part of the work. For this Item, the word "products" includes processes.

5.3. **Selection Options**. Pre-approved products: Construction products of certain manufacturers or suppliers designated in this Item as "pre-approved." The Department maintains a list of pre-approved products. Pre-approved products for this Project are designated as pre-approved in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.

Pre-qualified products: Construction products of certain manufacturers or suppliers designated in Specifications as "pre-qualified." Pre-qualified products for this Project are designated as pre-qualified in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.

Approved products: Construction products of certain manufacturers or suppliers designated in Specifications followed by words "or approved equal." Approval of alternate products not listed in Specifications may be obtained through provisions for product options and substitutions by Engineer and by following submittal procedures. The procedure for approval of alternate products is not applicable to pre-approved or pre-qualified products.

Product compatibility: To the maximum extent possible, provide products that are of the same type or function from a single manufacturer, make, or source.

Where more than one choice is available, select product that is compatible with other products already selected, specified, or in use by the Department.

5.4. **Contractor's Responsibility**. Responsibility related to product options and substitutions is defined in these Specifications.

Furnish information the Engineer deems necessary to judge equivalency of alternate product.

Pay for laboratory testing, as well as any other review or examination costs, needed to establish equivalency between products to obtain information upon which the Engineer can base a decision.

If the Engineer determines alternate product is not equal to that named in the Specifications, furnish one of the specified products.

5.5. **Department Review**. Use alternate products only when approved in writing. The Engineer's determination regarding acceptance of proposed alternate product is final.

Alternate products may be accepted if the products are judged to be equivalent to specified product or to offer substantial benefit.

5.6. **Substitution Procedure**. Collect and assemble technical information applicable to the proposed product to aid in determining equivalency as related to the approved product specified.

Submit a written request for a construction product to be considered as an alternate product.

Submit product information after the effective date of the Contract and within the time allowed for substitution submittals. After the submittal period has expired, requests for alternate products will be considered only when the specified product becomes unavailable because of conditions beyond the Contractor's control.

Submit five copies of each request for alternate product approval. Include the following information:

- Complete data substantiating compliance of proposed substitution with the Contract.
- For Products:
  - Product identification, including manufacturer's name and address.
  - Manufacturer's literature with product description, performance and test data, and reference standards.
  - Samples, as applicable.
- Name and address of similar projects on which product was used and date of installation. Include names of Owner, design consultant, and installing Contractor.
- For Construction Methods.
  - Detailed description of proposed method.
  - Plans illustrating methods.
- Itemized comparison of proposed substitution with product or method specified.
- Data relating to changes in the Construction Schedule.
- Relation to separate Contracts, if any.
- Accurate cost data on proposed substitution in comparison with product or method specified.
- Other information requested.

Approved alternate products will be subject to the same review process as the specified product would have been for Shop Drawings, Product Data, and Samples.

6. BASIC PRODUCT REQUIREMENTS

Requirements for transportation, delivery, handling, and storage of products.

6.1. **Products**. Does not include machinery and equipment used for preparation, fabrication, conveying and erection of the work. Products may also include existing materials or components designated for reuse.

When the plans and Specifications require that installation of work, comply with manufacturer's printed instructions, obtain, and distribute copies of such instructions to parties involved in installation, including 2 copies to the Engineer. Maintain one set of complete instructions at jobsite during installation until completion.

Provide products from the fewest number of manufacturers as practical, to simplify spare parts inventory and to allow for maximum interchangeability of components. For multiple components of the same size, type, or application, use the same make and model of component throughout the work.

6.2. **Transportation**. Arrange for transportation, delivery, and handling of products required for timely completion of the work. Transport and handle products in conformance with the manufacturer's instructions. Consign and address shipping documents to proper party giving name of the Project and its complete street address. Shipments are to be delivered to the Contractor.

6.3. **Delivery**. Arrange deliveries of products to accommodate short-term site completion schedules and in ample time to facilitate inspection before installation. Avoid deliveries that cause lengthy storage or overburden of limited storage space. Coordinate deliveries to avoid conflict with the work and conditions at the site and to accommodate the following.

- work of other Contractors or the Department;
- Limitations of storage space;
- Availability of equipment and personnel for handling products;
- The Department's use of premises;
- Products delivered to the site are in the manufacturer's original, unopened, labeled containers. Immediately upon delivery, inspect shipment to assure;
- Product complies with requirements of the Contract;
- Quantities are correct;
- Containers and packages are intact; labels are legible; and
- Products are properly protected and undamaged.

6.4. **Product Handling**. Coordinate off-loading of products delivered to the site. If necessary during construction, move and relocate stored products at no additional cost. Provide equipment and personnel necessary to handle products, including those provided by the Department, by methods to prevent damage to products or packaging. Provide additional protection during handling as necessary to prevent breaking, scraping, marring, or otherwise damaging products or surrounding areas. Handle products in conformance with manufacturer's recommendations.

6.5. **Storage of Products**. Store and protect products in conformance with manufacturer's recommendations and requirements of these Specifications.

Make necessary provisions for safe storage of products. Place products to prevent damage to any part of the work or existing facilities and to maintain free access at all times to all parts of the work and to utility service company installations in the vicinity of the work. Keep products neatly and compactly stored in locations that will cause minimum inconvenience to other Contractors, public travel, adjoining owners, tenants, and occupants. Arrange storage in a manner to provide easy access for inspection.

Provide off-site storage and protection when onsite storage is not adequate. Provide addresses of, and access to, off-site storage locations for inspection.

Do not use lawns, grass plots, or other private property for storage purposes without written permission of owner or other person in possession or control of premises.

Protect stored products against loss or damage.

Neatly, safely, and compactly stack products delivered and stored along the line of the work to avoid inconvenience and damage to property owners and the general public and maintain at least 3 ft. clearance around fire hydrants. Keep public, private driveways, and street crossings open.

Repair or replace damaged lawns, sidewalks, streets, or other improvements to the satisfaction of the Engineer. The total length that products may be distributed along route of construction at one time is 1000 ft., unless otherwise approved in writing.

7. STARTING SYSTEMS

This section includes starting systems, demonstration and instructions, and testing, adjusting, and balancing.

7.1. **Preparation**. Coordinate schedule for start-up of various equipment and systems.

Notify Engineer 7 days before start-up of each item.

Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions which may cause damage.

Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.

Verify wiring and support components for equipment are complete and tested.

Execute start-up under the Contractor's supervision in conformance with the manufacturer's instructions.

When specified in Specification sections, require the manufacturer to provide an authorized representative to be present at the site to inspect, check, and approve equipment or the system installation before start-up, and to supervise placing equipment or the system in operation.

Submit a written report that the equipment or system has been properly installed and is functioning correctly.

7.2. **Demonstration and Instructions**. Demonstrate operation and maintenance of products to the Engineer or their representatives 2 weeks before Substantial Completion.

Utilize operation and maintenance manuals as basis for instruction. Review contents of the manual with the Engineer or their representatives in detail to explain aspects of operation and maintenance.

Demonstrate start-up, operation, control, adjustment, troubleshooting, servicing, maintenance, and shutdown of each item of equipment at agreed-upon times, at the equipment location.

Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

7.3. **Testing, Adjusting, and Balancing**. The Contractor will appoint, employ, and pay for services of an independent firm to perform testing, adjusting, and balancing.

Reports will be submitted by the independent firm to the Engineer indicating observations and results of tests and indicating compliance or non-compliance with specified requirements and with the requirements of this Item.

8. CONSTRUCTION DEWATERING

Any dewatering required during any phase of construction is the responsibility of the Contractor. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this Specification for construction dewatering.

9. MEASUREMENT

The operational building, electrical power and controls, electrical pumps, generators, wet wells, and piping satisfactorily completed in conformance with the plans and Specifications to form a fully functional automatic pumping station will be measured by each complete unit.

10. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Automatic Pumping Station-SH 6," at the location specified. This price is full compensation for furnishing and installing a fully operational automatic pumping

station and for the equipment required by this Item including buildings, generators, pumps, discharge pipes, sensors, controls, switchgear, electrical systems, wet well, furnishing temporary pumps maintaining existing pumping rate during construction, and for other materials, labor, tools, equipment, accessories, and incidentals. Any costs associated with providing temporary power and electrical equipment, including but not limited to generators, panelboards, wiring, and starters to keep existing station in operation during construction, dewatering, electrical service, and testing are subsidiary to this Item. The work performed, materials furnished, equipment, labor, tools, and incidentals for construction of the wet well will not be paid for directly but are subsidiary to this Item.

Any dewatering required during any phase of construction is the responsibility of the Contractor and is subsidiary to this Item. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this Specification for construction dewatering.