CITY OF HOUSTON

DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
ENGINEERING AND CONSTRUCTION DIVISION

WATER CONTROL AND IMPROVEMENT DISTRICT #111
WASTEWATER TREATMENT PLANT
IMPROVEMENTS

WBS NO. R-000265-0129-3

VOLUME 1 OF 1
SPECIFICATIONS

PRELIMINARY
FOR REVIEW ONLY

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BIDDING OR PERMIT PURPOSES.
THEY WERE PREPARED BY, OR
UNDER SUPERVISION OF:
ROBERT T. THOMPSON,
P.E. 70201
JULY 22, 2016

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TEXAS P.E. FIRM NO. 3369

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END OF DOCUMENT

Document 00410A

BID FORM – PART A

To: **The Honorable Mayor and City Council of the City of Houston**
City Hall Annex
900 Bagby Street
Houston, Texas 77002

Project: *Water Control and Improvement District #111 Wastewater Treatment Plant Improvements*
Project No.: *WBS No. R-000265-0129-3*
Bidder: _____
(Print or type full name of proprietorship, partnership, corporation, or joint venture.)

1.0 OFFER

A. Total Bid Price: Having examined the Project location and all matters referred to in Bid Documents for the Project, we, the undersigned, offer to enter into a Contract to perform the Work for the Total Bid Price shown on the signature page of this Document

B. Security Deposit: Included with the Bid is a Security Deposit in the amount of 10 percent of the Total Bid Price subject to terms described in Document 00200 – Instructions to Bidders.

C. Period for Bid Acceptance: This offer is open to acceptance and is irrevocable for 90 days from Bid Date. That period may be extended by mutual written agreement of the City and Bidder.

D. Addenda: All Addenda have been received. Modifications to Bid Documents have been considered and all related costs are included in the Total Bid Price.

E. Bid Supplements: The following documents are attached:

[X] Security Deposit *(as defined in Document 00200 – Instructions to Bidders)*
[X] Document 00450 - Bidder's Statement of MWBE/PDBE/DBE/SBE Status
[X] Document 00452 - Contractor's Submission List - Fair Campaign Ordinance Form A
[X] Document 00453 – Bidder's Statement of Residency *(not required for AIP funded project)*
[X] Document 00454 - Affidavit of Non-interest
[X] Document 00455 - Affidavit of Ownership or Control
[ ] Document 00456 - Bidder's Certificate of Compliance with Buy American Program *(required for AIP funded project)*
[X] Document 00457 – Conflicts of Interest Questionnaire
[ ] Document 00458 - Bidder's Certificate Regarding Foreign Trade Restriction *(required for AIP funded project)*
[ ] Document 00459 - Contractor's Statement Regarding Previous Contracts Subject to EEO *(required for AIP funded project)*
[X] Document 00470 – Pay or Play Acknowledgement Form (POP+1-A)
[ ] Others as listed: _____

2.0 CONTRACT TIME

A. If offer is accepted, Contractor shall achieve Date of Substantial Completion within 565 days after Date of Commencement of the Work, subject to adjustments of Contract Time as provided in the Contract.

Document 00410B

BID FORM – PART B

1.0 TOTAL BID PRICE HAS BEEN CALCULATED BY BIDDER, USING THE FOLLOWING COMPONENT PRICES AND PROCESS (PRINT OR TYPE NUMERICAL AMOUNTS):

A. STIPULATED PRICE: $[N/A]

(Total Bid Price; minus Base Unit Prices, Extra Unit Prices, Contractor Incentive/bonus, Cash Allowances and All Alternates, if any)

Item No.	Control No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in figures
1.	01502	Mobilization	LS	1	$ 250,000	$250,000
2.	Div 0-16	Influent Lift Station Improvements	LS	1		
3.	Div 0-16	Headworks Facility Improvements	LS	1		
4.	Div 0-16	Aeration Tanks Gates Improvements	LS	1		
5.	Div 0-16	Return Activated Sludge Pump Station Improvements	LS	1		
6.	Div 0-16	Air Distribution Piping Repair	LS	1		
7.	Div 0-16	Scum Pump Station Improvements	LS	1		
8.	Div 0-16	Chlorine Contact Basins Improvements	LS	1		
9.	Div 0-16	Non-Potable Water System Improvements	LS	1		
10.	Div 0-16	New CCB Area Electrical Building	LS	1		
11.	Div 16	Exterior Lighting	LS	1		
TOTAL BASE UNIT PRICES						$_____

C. EXTRA UNIT PRICE TABLE:

Item No.	Control No.	Item Description	Unit Measure	Unit Quantity	Unit Price (this column controls)	Total in figures
1.	02221	Remove and dispose of miscellaneous concrete and masonry	CY	500	_____ ($30.00)(2)	_____ [$15,000.00] (2)
2.	02318	Excavation around obstructions	CY	750	_____ ($10.00) (2)	_____[$7,500.00] (2)
3.	02318	Extra hand excavation	CY	200	_____ ($21.00)(2)	_____ [$4,200.00] (2)
4.	02318	Extra machine excavation	CY	200	_____ ($10.50)(2)	_____ [$2,100.00] (2)
5.	02318	Extra placement of backfill material	CY	750	_____ ($15.50)(2)	_____ [$11,625.00] (2)
6.	02318	Extra placement of granular	CY	500	_____ ($10.00)(2)	_____ [$5,000.00] (2)
7.	02318	Extra cement-stabilized sand	CY	100	_____ ($31.50)(2)	_____ [$3,150.00] (2)
8.	03315	Extra class "A" concrete with or without forms	CY	100	_____ ($50.00)(2)	_____ [$5,000.00] (2)
TOTAL EXTRA UNIT PRICES						_____ [$53,575.00] (2)

D. CASH ALLOWANCE TABLE:

Cash Allowance No.	Cash Allowance Short Title	Cash Allowance in figures
1.	Building permit and water service fees, including water meter	$30,000.00
2.	Centerpoint Energy	$5,000.00
TOTAL CASH ALLOWANCES		$20,000.00

F. **TOTAL BID PRICE:** **$**_____
(Add Totals for Items A., B., C., D., E., and F. above)

2.0 SIGNATURES: By signing this Document, I agree that I have received and reviewed all Addenda and considered all costs associated with the Addenda in calculating the Total Bid Price.

Bidder: _____
(Print or type full name of your proprietorship, partnership, corporation, or joint venture.*)

** By: _____
Signature Date

Name: _____
(Print or type name) Title

Address: _____
(Mailing)

_____
(Street, if different)

Telephone and Fax Number: _____
(Print or type numbers)

* If Bid is a joint venture, add additional Bid Form signature sheets for each member of the joint venture.

** Bidder certifies that the only person or parties interested in this offer as principals are those named above. Bidder has not directly or indirectly entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding.

Note: This document constitutes a government record, as defined by § 37.01 of the Texas Penal Code. Submission of a false government record is punishable as provided in § 37.10 of the Texas Penal Code.

Footnotes for Tables B through E:
(1) Fixed Unit Price determined prior to Bid. Cannot be adjusted by the Bidder.
(2) Minimum Bid Price determined prior to Bid. Can be increased by the Bidder by crossing out the Minimum and noting revised price on the line above.
(3) Maximum Bid Price determined prior to Bid. Can be decreased but not increased by Bidder by crossing out the Maximum and noting revised price on the line above. A Bid that increases the Maximum Bid Price may be found non-conforming and non-responsive.
(4) Fixed Range Bid Price determined prior to Bid. Unit Price can be adjusted by Bidder to any amount within the range defined by crossing out prices noted and noting revised price on the line above.

END OF DOCUMENT

SECTION 01110
SUMMARY OF WORK

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Summary of Work including work by the City, City-furnished Products, work sequence, future work, Contractor use of Premises, special conditions for substantial completion and City occupancy.

1.02 WORK COVERED BY CONTRACT DOCUMENTS

A. Work of the Contract is for construction of Beltway Wastewater Treatment Plant Improvements. The Work to be performed under these Contract Documents is generally described as improvements to the existing Treatment Plant, which are generally listed below.

1. Influent Lift Station Improvements:
   a. Replace all four pumps with four new equally sized pumps (all on ASDs).
   b. Construct new electrical building separate from the lift station at elevation to meet City of Houston floodplain ordinance.
2. Headworks Facility improvements:
   a. Replace bar screen with new 1/4-inch opening bar screen.
   b. Replace building HVAC system.
   c. Provide space for future grit system in the new electrical building (combined with influent lift station electrical equipment).
3. Aeration Tank Gates Improvements:
   a. Modify structural support of seven existing gates on aeration tanks to improve stability.
   b. Replace seven gates on the aeration tanks at locations shown.
4. Return Activated Sludge Pump Station Improvements:
   a. Replace temporary submersible pumps with three new submersible pumps all on ASDs.
   b. Install new discharge manifold and piping. Install two new flow meters and two new flow control valves.
   c. Modify structural configuration of the return activated sludge wet well.
   d. Isolate screw pump chambers and Parshall flume. Install new grating and railing.
   e. Install three new level elements in the three chambers of the return activated sludge wet well.

5. Process Air Piping Leaks Repair: Replace underground air piping tall underground air piping that is leaking.
6. Scum Pump Station Improvements:
   a. Replace scum pumps with new submersible recirculator chopper pumps.
   b. Replace 4-inch scum piping with new piping to simplify configuration.
   c. Modify structural configuration of the scum wet well.
   d. Install a new spray bar across the new scum box to spray the surface during pumping.
   e. Install level transmitter in the new scum box.
7. Chlorine Contact Basin Improvements:
   a. Demolish existing Clari-vac sediment removal system.
   b. Install two new telescoping valves, one per basin.
   c. Install baffle walls in each basin to assist floatables collection and removal by the telescoping valves.
   d. Install a new walkway across the CCBs to provide access to the new telescoping valves.
8. Non- Potable Water System (NPWS) Improvements:
   a. Demolish existing five NPW pumps (three horizontal end suction and two vertical turbine) and replace with three new vertical turbine pumps.
   b. Install two new self-backwashing basket strainers on the new vertical turbine pump discharge.
   c. Demolish and replace hydro-pneumatic tank.
   d. Demolish and replace air compressor for the new NPW System.
9. CCB Area Electrical Building: Construct new electrical building elevation to meet City of Houston floodplain ordinance. This building shall house electrical gear from the existing chlorine building.
10. Exterior Lighting Improvements:
    a. Replace existing high pressure sodium cobra fixtures with LED retrofit kits.
    b. Install individual pole circuit protection fuses.

1.03 CASH ALLOWANCES

A. Include the following specific Cash Allowances in Contract Price under provision of General Conditions Paragraph 3.11: Building Permit Fee.

1.04 CITY FURNISHED PRODCUTS

A. None.

B. Contractor's Responsibilities:

1. Arrange and pay for Product delivery to the Site.
2. Receive and unload Products at the site; jointly with the City, inspect for completeness or damage.
3. Handle, store, install and finish Products.
4. Repair or replace damaged items.

1.05 WORK SEQUENCE

A. Construct the Work in Phases during the construction period, coordinate construction schedule and operations with the City:

1. No Phases for this Project.

B. For Projects with no Phases, do not disturb more than 50 percent of the total project linear feet of disturbed right-of-way and easement until site restored in accordance with Section 01740, Site Restoration.

C. Coordination of Work: refer to Section 01312, Coordination and Meetings.

D. For the replacement of air piping, Contractor may take down air supply piping for the following maximum durations at any given time:

1. Aeration Tanks: 4 hours maximum outage

1.06 EXISTING EQUIPMENT DESIGNATED FOR DEMOLITION/REMOVAL

A. The City shall have first right of refusal to retain all items shown to be demolished and/or removed in the drawings except for items listed in paragraph B. below which become the property of the Contractor. Prior to initiating demolition, the Contractor and City Engineer shall make a joint inspection of each site to identify all items to be retained by the City. The Contractor shall relocate items, to be retained by the City, to locations within the City limits to be determined by the City Engineer at time of the inspection. All other items shown to be demolished and/or removed, which are not retained by the City, shall become the property of the Contractor. The Contractor shall remove these items from City property and dispose of these items in accordance with Federal, State and Local regulations.

B. Removed and/or abandoned equipment which becomes the property of the Contractor is listed below. The below listed items become the Contractors property in addition to all items refused during site walks prior to demolition.

1. Existing MCC-C located in the existing Lift Station Building.
2. Existing transformer feeding MCC-C, at the Lift Station.

3. Existing MVS-3 Lift Station pad mounted oil filled switch.
4. Existing MVS-3A Lift Station pump motor starter.
5. Existing MVS-4 pad mounted oil filled switch located at the North Blower Building.
6. Abandoned equipment located East of the North Blower Building.
7. All removed medium voltage circuit conductors.

1.07 CONTRACTOR USE OF PREMISES

A. Comply with procedures for access to the site and Contractor's use of rights-of-way as specified in Section 01145, Use of Premises.

B. Construction Operations: Limited to the City's rights-of-way provided by the City and areas shown or described in the Contract Documents.

C. Utility Outages and Shutdown: Provide a minimum of 48 hours noticed to the City and private utility companies (when applicable), excluding weekends and holidays, in advance of required shutdown. Coordinate all work as required.

1.08 WARRANTY

A. Comply with warranty requirements in accordance with Document 00700, General Conditions.

1.09 ADDITIONAL CONDITIONS FOR SUBSTANTIAL COMPLETION

A. In addition to requirements outlined in Document 00700, General Conditions, for Contractor to be substantially complete with the Work and call for inspection by Project Manager to confirm, the following conditions must be met or completed:

1. All testing shall be completed and accepted by Project manager.
2. All SCADA/control related work shall be complete and accepted by manufacturer's representative and approved for operation.
3. FINAL O&M manuals shall be submitted, approved and delivered to the Project Manager.
4. Training shall be conducted. Note that training shall be conducted after the equipment/facility has had a seven consecutive day successful operation without malfunction.
5. All safety related work including pavement stripping, signing and signalization shall be complete.
6. All safety-related systems and equipment shall be installed, accepted by manufacturer's representative and approved for use.
7. Contractor shall contact Construction Project Manager to complete Texas Department of Licensing and Regulation Post Construction Inspection of pedestrian elements for Texas Accessibility Standards.

B. No additional condition described in Paragraph 1.10 may be included in Contractor's punch list.

C. This Contract has improvements in ten process areas of the Wastewater Treatment Plant. These ten areas are defined as Influent List Station, Headworks Facility, Aeration Tanks, Air Distribution Piping, Return Activated Sludge Pump Station, Scum Pump Station, Chlorine Contact Basins, NPW System, CCB Area Electrical Building and Exterior Lighting. When requested by the Contractor, the City shall give eight independent partial substantial completions as and when improvements in each area is completed as defined in Section 01110 item 1.09A. This shall allow warranty to start at the particular area of the plant from the date of its partial substantial completion. However, the project retainage will not be reduced at this time. When all the work and associated requirements in the tenth and final area is completed, Contractor will be given full substantial completion for the while project, at which time the warranty will commence on all project areas as well as the retainage reduction will occur for the Contract as a whole.

D. Acceptance as noted under warranty in the individual equipment specification begins from the date of substantial completion for that individual process area and not the individual equipment in that process area. For example, the NPW System has three vertical turbine pumps, two strainers, one hydro-pneumatic tank and one air compressor which will be released for work sequence one item at a time. Partial substantial completion will be given for NPW System only after all the work in the area is completed.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01451
SPECIAL INSPECTION, OBSERVATION, AND TESTING

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for Special Inspection, Observation, and Testing required in accordance with Chapter 17 of the 2012 International Building Code and is in addition to and supplements requirements included in Statement of Special Inspections (Plan) included as a supplement to this Specification.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. International Code Council (ICC):
   a. 2012 International Building Code (IBC).
   b. Evaluation Service (ICC-ES) Reports and Legacy Reports.
2. American Society of Civil Engineers (ASCE): 7-10, Minimum Design Loads for Buildings and Other Structures.

1.03 DEFINITIONS

A. Agencies and Personnel:

1. Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved.
2. Registered Design Professional in Responsible Charge: An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the Project is to be constructed.
3. Special Inspector: Qualified person employed by Owner who will demonstrate competence to the satisfaction of the building official for inspection of a particular type of construction or operation requiring Special Inspection.

B. Special Inspection:

1. Special Inspection: Inspection required of materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved Contract Documents and referenced standards.
2. Special Inspection, Continuous: Full-time observation of work requiring Special Inspection by an approved Special Inspector who is present in the area where the Work is being performed.
3. Special Inspection, Periodic: Part-time or intermittent observation of work requiring Special Inspection by an approved Special Inspector who is present in the area where the Work has been or is being performed, and at the completion of the Work.

C. Structural Systems and Components:

1. Diaphragm: Component of structural lateral load resisting system consisting of roof, floor, or other membrane or bracing system acting to transfer lateral forces to vertical resisting elements of structure.
2. Drag Strut or Collector: Component of structural lateral load resisting system consisting of a diaphragm or shear wall element that collects and transfers diaphragm shear forces to vertical force-resisting elements or distributes forces within diaphragm or shear wall.
3. Seismic-Force-Resisting System: That part of structural lateral load resisting system that has been considered in the design to provide required resistance to seismic forces identified on Drawings.
4. Shear Wall: Component of structural lateral load resisting system consisting of a wall designed to resist lateral forces parallel to the plane of the wall. Unless noted otherwise on Drawings, load-bearing walls with direct in-plane connections to roof and floors shall be considered to be shear walls.
5. Wind Force Resisting System: That part of the structural system that has been considered in the design to provide required resistance to wind forces identified on Drawings.

D. Nonstructural Components:

1. Architectural Component Supports: Structural members or assemblies of members which transmit loads and forces from architectural systems or components to the structure, including braces, frames, struts, and attachments.
2. Electrical Component Supports: Structural members or assemblies which transmit loads and forces from electrical equipment to the structure, including braces, frames, legs, pedestals, and tethers, as well as elements forged or cast as part of component for anchorage.

3. Mechanical Component Supports: Structural members or assemblies which transmit loads and forces from mechanical equipment to the structure, including braces, frames, skirts, legs, saddles, pedestals, snubbers, and tethers, as well as elements forged or cast as part of component for anchorage.

E. Professional Observation:

1. Does not include or waive responsibility for required Special Inspection or inspections by building official.
2. Requirements are indicated on Statement of Special Inspections (Plan) included as a supplement to this Specification.
3. Geotechnical Observation: Visual observation of selected subgrade bearing surfaces by a registered design professional for general conformance to Contract Documents.
4. Statement of Special Inspections (Plan): Detailed written procedure contained on Drawings establishing systems and components subject to Special Inspection, Observation, and Testing during construction, type and frequency of testing, extent and duration of Special Inspection, and reports to be completed and distributed by Special Inspector.

1.04 STATEMENT OF SPECIAL INSPECTIONS REQUIREMENTS

A. Designated Systems for Inspection:

1. Seismic-force-resisting systems designated under IBC Section 1705 and subject to Special Inspection: None required.
2. Wind-force-resisting systems designated under IBC Section 1705: None required.
3. Architectural, Mechanical, and Electrical Components subject to Special Inspection and testing under IBC Section 1705.11 for Seismic Resistance: None required**.**

B. Statement of Special Inspections:

1. As included as a supplement to this Specification and in support of the building permit application, the Project specific plan was prepared by the registered design professional in responsible charge. The following identifies elements of the inspection, observation and testing program to be followed in construction of the Work:
   a. Special Inspection and testing required by IBC Section 1705, and other applicable sections and referenced standards therein.
   b. Type and frequency of Special Inspection required.
   c. Type and frequency of testing required.

d. Required frequency and distribution of testing and Special Inspection reports to be distributed by Special Inspector to Engineer, Contractor, building official, and Owner.
e. Geotechnical Observation to be Performed: Required frequency and distribution of Geotechnical Observation reports by registered design professional to Contractor, building official, and Owner.

C. Special Inspection and associated testing of shop fabrication and field construction will be performed by an approved accredited independent agency. Owner will secure and pay for the services of the agency to perform Special Inspection and associated testing.

D. Owner's plan for code required Special Inspection with associated testing and Professional Observation, as provided in Statement of Special Inspections is for the sole benefit of Owner and does not:

1. Relieve Contractor of responsibility for providing adequate quality control measures.
2. Relieve Contractor of responsibility for damage to or loss of material before acceptance.
3. Constitute or imply acceptance.
4. Affect continuing rights of Owner after acceptance of completed Work.

E. The presence or absence of code required Special Inspector and Professional Observer does not relieve Contractor from Contract requirements.

F. Contractor is responsible for additional costs associated with Special Inspection and Testing and Observation when Work is not ready at time identified by Contractor, and Special Inspectors and Professional Observer are on Site but not able to provide contracted services.

G. Contractor is responsible for associated costs for additional Special Inspection and Testing and Professional Observation by Special Inspectors and Professional Observers required due to rejection of materials of in place Work that cannot be made compliant to Contract Document without additional Site visits or testing.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Provide access to shop or Site for Special Inspection and Testing and Professional Observation.

B. Notify Engineer in advance of required Special Inspection and Professional Observation no later than 48 hours prior to date of Special Inspection and Professional Observation.

C. Materials and systems, inclusive, shall be inspected during placement where Continuous Special Inspection is required.

D. Materials and systems shall be inspected during or at completion of their placement where Periodic Special Inspection is allowed.

1. Periodic Special Inspection shall be performed so that Work inspected after, but not during, its placement can be corrected prior to other related Work proceeding and covering inspected Work.
2. Periodic Special Inspection does not allow sampling of a portion of the Work. All Work shall be inspected.

3.02 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Supplement 1, Statement of Special Inspections.
2. Supplement 2, Table 1: Required Non-structural Special Inspection.
3. Supplement 3, Table 2: Required Structural Special Inspection.
4. Supplement 4, Table 3: Testing for Required Special Inspection.

END OF SECTION

STATEMENT OF SPECIAL INSPECTIONS PLAN

GENERAL NOTES

1. THE STATEMENT OF SPECIAL INSPECTIONS PROVIDE PROJECT COMPLIANCE WITH THE PROVISIONS OF THE INTERNATIONAL BUILDING CODE (IBC) CHAPTER 17 FOR SPECIAL INSPECTION, STRUCTURAL OBSERVATION, AND TESTING FOR WIND AND SEISMIC RESISTANCE AS APPLICABLE. THIS INSPECTION IS OWNER FURNISHED.
2. STANDARD SPECIAL INSPECTION REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS ARE CONTAINED IN TABLE 1.
3. STANDARD SPECIAL INSPECTION REQUIREMENTS FOR STRUCTURAL COMPONENTS, IRREGARDLESS OF WIND OR SEISMIC DESIGN CATEGORIES, ARE CONTAINED IN TABLE 2.
4. STANDARD TESTING REQUIREMENTS FOR STRUCTURAL COMPONENTS ARE CONTAINED IN TABLE 3.
5. FOR ADDITIONAL REQUIREMENTS, REFER TO SPECIFICATION SECTION 01451, SPECIAL INSPECTION, OBSERVATION AND TESTING. THESE INCLUDE:

   A. CONTRACTOR'S REQUIREMENTS TO PROVIDE ACCESS TO THE WORK FOR REQUIRED INSPECTIONS, AND TO PROVIDE NOTICE OF REQUIRED INSPECTIONS AND STRUCTURAL OBSERVATION.
   B. DEFINITIONS AND TERMINOLOGY USED IN THIS PLAN.

SPECIAL INSPECTION

1. SPECIAL INSPECTION WILL BE IN ACCORDANCE WITH IBC SECTION 1704 TOGETHER WITH LOCAL AND STATE AMENDMENTS. REFER TO THE TABLES CONTAINED ON THESESUPPLEMENTAL SECTIONS FOR PROJECT SPECIFIC INSPECTION TYPES AND FREQUENCIES.
2. SPECIAL INSPECTIONS AND ASSOCIATED TESTING SHALL BE PERFORMED BY AN APPROVED ACCREDITED INDEPENDENT AGENCY. THE OWNER WILL SECURE AND PAY FOR THE SERVICES OF THE AGENCY TO PERFORM ALL SPECIAL INSPECTION AND ASSOCIATED TESTS. INSPECTORS FOR EACH SYSTEM AND MATERIAL WILL BE INTERNATIONAL CODE COUNCIL (ICC) CERTIFIED OR OTHERWISE APPROVED BY THE BUILDING OFFICIAL.

3. THE SPECIAL INSPECTOR WILL OBSERVE THE INDICATED WORK FOR COMPLIANCE WITH THE APPROVED CONTRACT DOCUMENTS AND SUBMIT RECORDS OF INSPECTION. ALL DISCREPANCIES WILL BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE CONTRACTOR FOR CORRECTION.
4. SPECIAL INSPECTION AND ASSOCIATED TESTING REPORTS WILL BE SUBMITTED TO THE ENGINEER, CONTRACTOR, BUILDING OFFICAL, AND OWNER WITHIN ONE WEEK OF INSPECTION OR WITHIN ONE WEEK OF TEST COMPLETION. INSPECTIONS FOR WHICH REPORTING WILL BE REQUIRED ARE NOTED IN THE TABLES CONTAINED IN THIS PLAN.
5. AT THE CONCLUSION OF CONSTRUCTION, A FINAL REPORT DOCUMENTING REQUIRED SPECIAL INSPECTIONS AND CORRECTION OF PREVIOUSLY NOTED DISCREPANCIES WILL BE SUBMITTED.

SPECIAL INSPECTIONS FOR WIND RESISTANCE

1. STATEMENT OF SPECIAL INSPECTIONS REQUIREMENTS FOR WIND RESISTANCE IN ACCORDANCE WITH IBC SECTION 1705.10 ARE NOT APPLICABLE TO THIS PROJECT.

SPECIAL INSPECTIONS FOR SEISMIC RESISTANCE

1. STATEMENT OF SPECIAL INSPECTIONS REQUIREMENTS FOR SEISMIC RESISTANCE IN ACCORDANCE WITH IBC SECTION 1705.11 ARE NOT APPLICABLE TO THIS PROJECT.

TABLE 1

REQUIRED NON-STRUCTURAL SPECIAL INSPECTION

REFER TO SPECIFICATION SECTION 01451

SYSTEM OR MATERIAL	2012 IBC CODE REFERENCE	REFERENCED STANDARD	PERIODIC OWNER FURNISHED SPECIAL INSPECTION (SEE NOTE 1)	CONTINUOUS OWNER FURNISHED SPECIAL INSPECTION	COMMENTS	TESTING FOR SPECIAL INSPECTION
GEOTECHNICAL						
1. SOILS:						
A. VERIFY MATERIALS BELOW SHALLOW FOUNDATIONS ARE ADEQUATE TO ACHIEVE THE DESIGN BEARING CAPACITY	1705.6, 1803.5.8, 1804.5	SECTION 2319, SUBGRADE PREPARATION	X		PROFESSIONAL OBSERVATION BY GEOTECHNICAL ENGINEER	
B. VERIFY EXCAVATIONS ARE EXTENDED TO PROPER DEPTH AND HAVE REACHED PROPER MATERIAL	1705.6	SECTION 2315, EXCAVATION	X		PROFESSIONAL OBSERVATION BY GEOTECHNICAL ENGINEER	
C. PERFORM CLASSIFICATION AND TESTING OF COMPACTED FILL MATERIALS	1705.6	SECTION 2316, FILL AND BACKFILL	X			SEE TABLE 3 FOR GRADATION TEST REQUIREMENTS
D.VERIFY USE OF PROPER MATERIALS, DENSITIES, AND LIFT THICKNESSES DURING PLACEMENT AND COMPACTION OF COMPACTED FILL	1705.6, 1803.5.8	SECTION 2316, FILL AND BACKFILL		X		SEE TABLE 3 FOR DENSITY TEST REQUIREMENTS

E. PRIOR TO PLACEMENT OF COMPACTED FILL, OBSERVE SUBGRADE AND VERIFY THAT SITE HAS BEEN PREPARED PROPERLY	1705.6	SECTION 2319, SUBGRADE PREPARATION	X		PROFESSIONAL OBSERVATION BY GEOTECHNICAL ENGINEER	SEE TABLE 3 FOR DENSITY TEST **[AND PROOF ROLLING]** REQUIREMENTS
2. CAST-IN-PLACE DEEP FOUNDATION ELEMENTS:						
A. OBSERVE DRILLING OPERATIONS AND MAINTAIN COMPLETE AND ACCURATE RECORDS FOR EACH ELEMENT	1705.8			X		
B. VERIFY PLACEMENT LOCATIONS AND PLUMBNESS, CONFIRM ELEMENT DIAMETERS, BELL DIAMETERS (IF APPLICABLE), LENGTHS, EMBEDMENT INTO BEDROCK (IF APPLICABLE), AND ADEQUATE END BEARING STRATA CAPACITY. RECORD CONCRETE OR GROUT VOLUMES.	1705.8			X	PROFESSIONAL OBSERVATION BY GEOTECHNICAL ENGINEER	SEE TABLE 3 FOR PILE INTEGRITY TESTING
C. FOR CONCRETE ELEMENTS, PERFORM ADDITIONAL INSPECTIONS IN ACCORDANCE WITH SECTION 1705.3	1705.8				SEE TABLE 2 FOR REQUIRED INSPECTIONS FOR CONCRETE CONSTRUCTION	
GENERAL						

1. CONSTRUCTION MATERIALS AND SYSTEMS THAT ARE ALTERNATIVES TO MATERIALS AND SYSTEMS PRESCRIBED BY CODE	1705.1.1 ITEM 1		X			
2. UNUSUAL DESIGN APPLICATION OF CODE MATERIALS	1705.1.1 ITEM 2			X		
3. INSTALLATION OF MATERIALS THAT REQUIRE ADDITIONAL MANUFACTURER'S INSTRUCTIONS BEYOND CODE REQUIREMENTS	1703.4.2, 1705.1.1 ITEM 3	ICC-ES EVALUATION REPORTS		X		
STRUCTURAL						
SEE TABLE 2.						

NOTES:

1. PERIODIC INSPECTION IS DEFINED AS INSPECTION BY THE SPECIAL INSPECTOR OF ALL MATERIALS AND SYSTEMS, IN SOME CASES PERFORMED DURING THEIR PLACEMENT AND IN ALL CASES PERFORMED UPON COMPLETION OF THEIR PLACEMENT. THE COMPLETION INSPECTION SHALL BE PERFORMED SO THAT WORK CAN BE CORRECTED PRIOR TO OTHER RELATED WORK PROCEEDING AND COVERING INSPECTED WORK.

TABLE 2

REQUIRED STRUCTURAL SPECIAL INSPECTION
REFER TO SPECIFICATION SECTION 01451

SYSTEM	2012 IBC CODE REFERENCE	REFERENCED STANDARD	PERIODIC OWNER FURNISHED SPECIAL INSPECTION (SEE NOTE 1)	CONTINUOUS OWNER FURNISHED SPECIAL INSPECTION	COMMENTS	TESTING FOR SPECIAL INSPECTION
CONCRETE						
1. INSPECTION OF REINFORCING STEEL, INCLUDING PRESTRESSING TENDONS, AND PLACEMENT	1705.3, 1903.1	ACI 318: 3.5, 7.1-7.7	X			SEE TABLE 6 FOR REINFORCING STEEL TESTING
2. INSPECTION OF ANCHORS CAST IN CONCRETE	1705.3, 1908.5, 1909.1	ACI 318: 8.1.3	X			

3. INSPECTION OF ANCHORS POST-INSTALLED IN HARDENED CONCRETE MEMBERS	1705.3, 1909.1	ACI 318: 3.8.6, 8.1.3, ICC-ES EVALUATION REPORTS	X		PROVIDE CONTINUOUS SPECIAL INSPECTION FOR ADHESIVE ANCHORS DESIGNED TO RESIST SUSTAINED TENSION LOADS AND WHERE REQUIRED BY ICC-ES REPORT	
4. VERIFYING USE OF REQUIRED DESIGN MIX	1705.3, 1904.2	ACI 318: Ch. 4, 5.2-5.4	X			
5. AT THE TIME FRESH CONCRETE IS SAMPLED TO FABRICATE SPECIMENS FOR STRENGTH TESTS, PERFORM SLUMP AND AIR CONTENT TESTS, AND DETERMINE THE TEMPERATURE OF THE CONCRETE	1705.3	ASTM C 172, ASTM C 31, ACI 318: 5.6, 5.8		X		SEE TABLE 3 FOR CONCRETE TEST REQUIREMENTS
6. INSPECTION OF CONCRETE PLACEMENT FOR PROPER APPLICATION TECHNIQUES	1705.3,	ACI 318: 5.9, 5.10		X		
7. INSPECTION FOR MAINTENANCE OF SPECIFIED CURING TEMPERATURE AND TECHNIQUES	1705.3	ACI 318: 5.11-5.13	X			

8. ERECTION OF PRECAST CONCRETE MEMBERS	1705.3	ACI 318: Ch. 16	X			
12. INSPECT FORMWORK FOR SHAPE, LOCATION AND DIMENSIONS OF THE CONCRETE MEMBER BEING FORMED	1705.3	ACI 318: 6.1.1	X			
13. INSPECTION OF WATERSTOPS FOR PROPER SHAPE, LOCATION, JOINT QUALITY, AND SURROUNDING CONCRETE PLACEMENT			X			
14. VERIFY PROPER INSTALLATION OF MECHANICAL REINFORCING SPLICES AND CONNECTIONS	1705.1.1 ITEM 3, 1705.3	ICC-ES EVALUATION REPORTS	X			
STRUCTURAL STEEL						
1. MATERIAL VERIFICATION OF STRUCTURAL STEEL:						
A. IDENTIFICATION MARKINGS TO CONFORM TO AISC 360	1705.2.1, 2203.1	Applicable ASTM Material Standards	X			
B. MANUFACTURER'S CERTIFIED TEST REPORTS	1705.2.1	AISC 360: Sec. N3.2, N5.2	X			
2. PRIOR TO BOLTING, VERIFY THAT THE FOLLOWING ARE IN COMPLIANCE:						

A. MANUFACTURER'S CERTIFICATIONS AVAILABLE FOR FASTENER MATERIALS	1705.2.1	AISC 360: Sec. N3.2, N5.2, N5.6 RCSC: Sec. 2.1, 9.1		X		
B. FASTENERS MARKED IN ACCORDANCE WITH ASTM REQUIREMENTS	1705.2.1	AISC 360: Sec. N3.2, N5.2, N5.6 Applicable ASTM Material Standards	X			
C. PROPER BOLTING PROCEDURE SELECTED FOR JOINT DETAIL	1705.2.1	AISC 360: Sec. N5.6 RCSC: Sec. 4	X			
D. PROPER STORAGE PROVIDED FOR BOLTS, NUTS, WASHERS AND OTHER FASTENER COMPONENTS	1705.2.1	AISC 360: Sec. N5.6 RCSC: Sec. 2.2	X			
3. VERIFY DURING BOLTING:						
A. FASTENER ASSEMBLIES, OF SUITABLE CONDITION, PLACED IN ALL HOLES AND WASHERS (IF REQUIRED) ARE POSITIONED AS REQUIRED	1705.2.1	AISC 360: Sec. N5.6	X			
B. JOINT BROUGHT TO SNUG-TIGHT CONDITION	1705.2.1	AISC 360: Sec. N5.6	X			
4. PRIOR TO WELDING, VERIFY THAT THE FOLLOWING ARE IN COMPLIANCE:						

A. APPROVED WELDING PROCEDURE SPECIFICATIONS (WPS) AVAILABLE TO WELDERS AND WELDING INSPECTOR(S)	1705.2.1	AWS D1.1	X			
B. WELDER QUALIFICATIONS AND JOINT FIT-UP	1705.2	AWS D1.1	X		NOTE 2	
5. VERIFY DURING WELDING:						
A. CONTROL AND HANDLING OF WELDING CONSUMABLES	1705.2.1	AWS D1.1	X			
B. ENVIRONMENTAL CONDITIONS	1705.2.1	AWS D1.1	X			
C. COMPLIANCE WITH WPS REQUIREMENTS	1705.2.1	AWS D1.1	X		NOTE 2	
6. AFTER WELDING, VERIFY THE FOLLOWING:						
A. SIZE, LENGTH AND LOCATION OF WELDS	1705.2.1	AWS D1.1	X		NOTE 2	
B. WELDS MEET VISUAL ACCEPTANCE CRITERIA	1705.2.1	AWS D1.1	X		NOTE 2	
C. BACKING REMOVED AND WELD TABS REMOVED (IF REQUIRED)	1705.2.1	AWS D1.1	X			
D. NONDESTRUCTIVE WELDING INSPECTION	1705.2	AWS D1.1	X		NOTE 2	
ALUMINUM						
1. MATERIAL VERIFICATION OF ALUMINUM:						

A. IDENTIFICATION MARKINGS TO CONFORM TO ASTM STANDARDS SPECIFIED IN THE APPROVED CONSTRUCTION DOCUMENTS	1705.1.1 ITEM 2		X			
B. MANUFACTURERS' CERTIFIED MILL TEST REPORTS	1705.1.1 ITEM 2		X			
3. INSPECTION OF WELDING:						
A. NONDESTRUCTIVE INSPECTION	1705.1.1 ITEM 2	AWS D1.2	X		NOTE 2	

NOTES:

1. PERIODIC INSPECTION IS DEFINED AS INSPECTION BY THE SPECIAL INSPECTOR OF ALL MATERIALS AND SYSTEMS, IN SOME CASES PERFORMED DURING THEIR PLACEMENT AND IN ALL CASES PERFORMED UPON COMPLETION OF THEIR PLACEMENT. THE COMPLETION INSPECTION SHALL BE PERFORMED SO THAT WORK CAN BE CORRECTED PRIOR TO OTHER RELATED WORK PROCEEDING AND COVERING INSPECTED WORK.

2. VISUAL INSPECTION IS THE RESPONSIBILITY OF THE CONTRACTOR'S WELDING INSPECTOR(S) AND IS NOT CONSIDERED SPECIAL INSPECTION. CONTRACTOR MUST PROVIDE A QUALIFIED WELDING INSPECTOR TO OVERSEE CONTRACTOR'S WELDING OPERATIONS, AS REQUIRED BY AWS D1.1, SECTIONS 6.1.2 & 6.6, SPEC. SECTION 05 05 23 AND REFERENCED WELDING CODES.

TABLE 3

TESTING FOR REQUIRED SPECIAL INSPECTION

REFER TO SPECIFICATION SECTION 01451

MATERIAL	TYPE OR SCOPE	STANDARD	2012 IBC CODE REFERENCE	FREQUENCY	BY WHOM	COMMENTS
GEOTECHNICAL						
COMPACTED FILL	GRADATION	ASTM C117, C136	1705.6	SECTION 2316, FILL AND BACKFILL	OWNER'S TESTING AGENCY	
COMPACTED FILL	COMPACTION	ASTM **[D698] [D1557]**	1705.6	SECTION 2316, FILL AND BACKFILL	OWNER'S TESTING AGENCY	
COMPACTED FILL	DENSITY	ASTM **[D1556] [D6938]**	1705.6	SECTION 2316, FILL AND BACKFILL	OWNER'S TESTING AGENCY	
PREPARED SUBGRADE	DENSITY	ASTM **[D698] [D1557]**	1705.6	SECTION 2319, SUBGRADE PREPARATION	OWNER'S TESTING AGENCY	
CONCRETE						
CONCRETE	STRENGTH	ASTM C39	1705.3	ONCE EACH DAY, BUT NOT LESS THAN ONE SAMPLE FOR EACH 150 CUBIC YARDS OR 5,000 SFT OF WALLS OR SLABS PLACED	OWNER'S TESTING AGENCY	
SHOTCRETE	STRENGTH	ASTM C42	1705.3, 1910.10	ONCE EACH SHIFT, BUT NOT LESS THAN ONE SAMPLE FOR EACH 50 CUBIC YARDS PLACED	OWNER'S TESTING AGENCY	
CONCRETE	SLUMP	ASTM C143, C94	1705.3	ONE SAMPLE PER STRENGTH TEST	OWNER'S TESTING AGENCY	

CONCRETE	AIR CONTENT	ASTM C231, C94	1705.3	ONE SAMPLE PER STRENGTH TEST	OWNER'S TESTING AGENCY	
CONCRETE	TEMPERATURE	ASTM C1064	1705.3	ONE SAMPLE PER STRENGTH TEST	OWNER'S TESTING AGENCY	

SECTION 03100
CONCRETE FORMWORK

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Design, construction, erection and removal of structural concrete formwork.

1.02 UNIT PRICES

A. No separate payment will be made for concrete formwork under this Section. Include payment in unit price for structural concrete.

B. Refer to Section 01270, Measurement and Payment for unit price procedures.

1.03 REFERENCE STANDARDS

A. ACI 117 - Standard Tolerances for Concrete Construction and Materials.

B. ACI 347 - Recommended Practice for Concrete Formwork.

C. U.S. Product Standard PS 1 Construction and Industrial Plywood.

D. U.S. Product Standard PS 20 American Softwood Lumber Standard.

1.04 SUBMITTALS

A. Conform to Section 01330, Submittal Procedures.

B. Shop Drawings: Show location, member size and loading of shoring. When reshoring is permitted, submit plans showing locations and member size of reshoring.

C. Product Data and Samples:

1. Form-coating Materials: Submit trade or brand names of manufacturers and complete description of products.
2. Form ties and related accessories, including taper tie plugs, if taper ties are used. Form gaskets.

D. Detailed Layout for Slip-forming: Submit detailed layout of proposed slipforming, including description of equipment, rate of progress, and other data to show suitability of method. Show provisions for ensuring attainment of required concrete surface finish.

PART 2 PRODUCTS

2.01 MATERIAL

A. Smooth Forms: New plywood, metal, plastic, tempered concrete-form hardboard, dressed lumber faced with plywood or fiberboard lining, or metal-framed plywood-faced panel material, to provide continuous, straight, smooth surfaces. Form material shall be free of raised grain, torn surfaces, worn edges, patches, dents or other defects. Furnish material in largest practical sizes to minimize number of joints and, when indicated on Drawings, conform to joint system indicated. Form material shall have sufficient strength and thickness to withstand pressure of newly placed concrete without bow or deflection.

B. Rough Forms: Plywood, metal, dressed or undressed lumber free of knots, splits or other defects, or other material acceptable to Project Manager of sufficient strength and thickness to withstand pressure of newly placed concrete without bow or deflection.

C. Plywood: Conform to PS 1, Class 1.

D. Lumber: Conform to PS 20.

E. Edge Forms and Intermediate Screed Strips: Type and strength compatible with the screed equipment and methods used.

F. Circular Forms:

1. Form round-section members with paper or fiber tubes, constructed of laminated plies using water-resistant adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation. Provide manufacturer's seamless units to minimize spiral gaps and seams.
2. Fiberglass or steel forms may be used for round-section members.

G. Shores: Wood or adjustable metal, with bearing plates; with double wedges at lower end.

H. Form Ties:

1. Use commercially-manufactured ties, hangers and other accessories for embedding in concrete. Do not use wire not commercially fabricated for use as a form accessory.

2. Fabricate ties so ends or end fasteners can be removed without causing spalling of concrete faces. Depth from formed concrete face to the embedded portion: At least 1 inch, or twice the minimum dimension of tie, whichever is greater.
3. Provide waterstop feature for form ties used on liquid-containing structures and on concrete walls which will have earth backfill on one side.
4. Removable ties: Taper ties may be used when approved by the Project Manager. In the hole left by the removal of the taper tie, insert a preformed neoprene or polyurethane plug sized to seat at the center of the wall.

I. Form Coating: Commercial formulation of form oil or form-release agent having proven satisfactory performance. Coating shall not bond with, stain or otherwise adversely affect concrete surfaces, or impair their subsequent treatment, including application of bonding agents, curing compounds, paint, protective liners and membrane waterproofing.

J. Coating for Plastic Forms: Alkali-resistant gel-coat.

K. Chamfer Strips: Unless otherwise indicated on Drawings, provide 3/4-inch chamfer strips in corners of forms to produce beveled edges where required by Part 3, Execution.

L. Form Gaskets: Polyethylene rod, closed cell, one-inch diameter.

2.02 DESIGN OF FORMWORK

A. Conform to ACI 117, ACI 347 and City building codes, unless more restrictive requirements are specified or shown on Drawings. Contractor shall design and engineer concrete formwork, including shoring and bracing. Design formwork for applicable gravity loads, lateral pressure, wind loads and allowable stresses. Camber formwork to compensate for anticipated deflection during placement of concrete when required to maintain specified tolerances. Design formwork to be readily removed without impact, shock or damage to concrete surfaces and adjacent materials.

B. Slip Forming: Permitted on written approval of City Engineer. Contractor shall demonstrate suitability of method proposed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Formwork Construction

1. Construct and maintain formwork so that it will maintain correct sizes of members, shape, alignment, elevation and position during concrete placement and until concrete has gained sufficient strength. Provide for required openings, offsets, sinkages, keyways, recesses, moldings, anchorages and inserts.
2. Construct forms for easy removal without damage to concrete surfaces.
3. Make formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide backup material at joints as required to prevent leakage and fins. Provide gaskets for wall forms to prevent concrete paste leakage at their base.
4. Place chamfer strips in forms to bevel edges and corners permanently exposed to view, except top edges of walls, and slabs which are indicated on Drawings to be tooled. Do not bevel edges of formed joints and interior corners unless indicated on Drawings. Form beveled edges for vertical and horizontal corners of equipment bases. Unless otherwise indicated on Drawings, make bevels 3/4 inch wide.
5. Provide temporary openings at bases of column and wall forms and other points as required for observation and cleaning immediately before concrete is placed.
6. Where runways are required for moving equipment, support runways directly on the formwork or structural members. Do not allow runways or supports to rest on reinforcing steel.
7. Use smooth forms on formed concrete surfaces required to have smooth form finish or rubbed finish as specified in Section 03350 - Concrete Finishing.
8. Rough forms may be used on formed concrete surfaces indicated to have rough form finish as specified in Section 03350 - Concrete Finishing.

B. Forms for Surfaces Requiring Smooth Form Finish:

1. Drill forms to suit ties used and to prevent leakage of concrete mortar around tie holes. Uniformly space form ties and align in horizontal and vertical rows. Install taper ties, if used, with the large end on the wet face of the wall.
2. Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back up joints with extra studs or girts to maintain true, square intersections.

3. Form molding shapes, recesses and projections with smooth-finish materials and install in forms with sealed joints to prevent displacement.
4. Form exposed corners of beams and columns to produce square, smooth, solid, unbroken lines.
5. Provide exterior exposed edges with 3/4-inch chamfer or 3/4-inch radius.
6. Arrange facing material in orderly and symmetrical fashion. Keep number of joints to practical minimum. Support facing material adequately to prevent deflection in excess of allowable tolerances.
7. For flush surfaces exposed to view in completed structure, overlap previously- placed hardened concrete with form sheathing by approximately 1 inch. Hold forms against hardened concrete to maintain true surfaces, preventing offsets or loss of mortar.
8. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure supports for types of screeds required.
9. Circular Forms: Set forms in one piece for full height of member.

C. Tolerances:

1. Unless noted otherwise on Drawings, construct formwork so concrete surfaces will conform to tolerance limits listed in Tables 03100A and 03100B at end of this Section.
2. Establish sufficient control points and bench marks as references for tolerance checks. Maintain these references in undisturbed condition until final completion and acceptance of the Work.

D. Adjustment of Formwork:

1. Use wedges or jacks to provide positive adjustment of shores and struts. After final inspection and before concrete placement, fasten in position wedges used for final adjustment of forms.
2. Brace forms securely against lateral deflections. Prepare to compensate for settling during concrete placement.
3. For wall openings, construct wood forms that facilitate necessary loosening to counteract swelling of forms.

3.02 PREPARATION OF FORM SURFACES

A. Clean surfaces of forms and embedded materials before placing concrete. Remove accumulated mortar, grout, rust and other foreign matter.

B. Coat forms for exposed or painted concrete surfaces with form oil or form-release agent before placing reinforcement. Cover form surfaces with coating material in accordance with manufacturer's printed instructions. Do not allow excess coating material to accumulate in forms or to contact hardened concrete against which fresh concrete will be placed. Remove coating material from reinforcement before placing concrete.

C. Forms for unexposed surfaces, other than retained-in-place metal forms, may be wet with water immediately before concrete placement in lieu of coating. When possibility of freezing temperatures exists, however, the use of coating is mandatory.

3.03 REMOVAL OF FORMS

A. Time Limits:

1. When repair of surface defects or finishing is required before concrete is aged, forms on vertical surfaces may be removed as soon as concrete has hardened sufficiently to resist damage from removal operations.
2. Remove top forms on sloping surfaces of concrete as soon as concrete has attained sufficient stiffness to prevent sagging. Loosen wood forms for wall openings as soon as this can be accomplished without damage to concrete. Leave formwork for water-retaining structures in place for at least 2 days. Formwork for non-water-retaining columns, walls, sides of beams and other formwork components not supporting weight of concrete may be removed after 12 hours, provided concrete has hardened sufficiently to resist damage from removal operations, and provided removal of forms will not disturb members supporting weight of concrete.
3. Forms and shoring supporting weight of concrete or construction loads: Leave in place until concrete has reached minimum strength specified for removal of forms and shoring. Do not remove such forms in less than 4 days.

B. Circular Paper or Spiral Tube Forms: Follow manufacturer's directions for form removal. Take necessary precautions to prevent damage to concrete surface. When removal is done before completion of curing time, replace form, tie in place and seal to retard escape of moisture.

C. Removal Strength:

1. Control Tests: Suitable strength-control tests will be required as evidence that concrete has attained specified strength for removal of formwork or shoring supporting weight of concrete in beams, slabs and other structural members. Furnish test cylinders and data to verify strength for early form removal.

2. Field-cured Test Cylinders: When field-cured test cylinders reach specified removal strength, formwork or shoring may be removed from respective concrete placements.
3. Laboratory-cured Test Cylinders: When concrete has been cured as specified for structural concrete for same time period required by laboratory-cured cylinders to reach specified strength, formwork or shoring may be removed from respective concrete placements. Determine length of time that concrete has been cured by totaling the days or fractions of days, not necessarily consecutive, during which air temperature surrounding concrete is above 50 degrees F and concrete has been damp or thoroughly sealed against evaporation and loss of moisture.
4. Compressive Strengths: The minimum concrete compressive strength for removal of formwork supporting weight of concrete is 75 percent of specified minimum 28-day strength for class of concrete involved.

3.04 RESHORING

A. When reshoring is permitted, plan operations in advance and obtain City Engineer's approval of such operations. While reshoring is under way, keep live load off new construction. Do not permit concrete in any beam, slab, column or other structural member to be subjected to combined dead and construction loads in excess of loads permitted for developed concrete strength at time of reshoring.

B. Place reshores as soon as practicable after form-stripping operations are complete but in no case later than end of day on which stripping occurs. Tighten reshores to carry required loads without over stressing construction. Leave reshores in place until tests representative of concrete being supported have reached specified strength at time of removal of formwork supporting weight of concrete.

C. Floors supporting shores under newly-placed concrete: Leave original supporting shores in place, or re-shore. Locate reshores directly under shore position above. Extend reshoring over a sufficient number of stories to distribute weight of newly-placed concrete, forms and construction live loads in such manner that design superimposed loads of floors supporting shores are not exceeded.

3.05 FORM REUSE

A. Do not reuse forms that are worn or damaged beyond repair. Thoroughly clean and recoat forms before reuse. For wood and plywood forms to be used for exposed smooth finish, sand or otherwise dress concrete contact surface to original condition or provide form liner facing material. For metal forms, straighten, remove dents and clean to return forms to original condition.

Table 03100A

TOLERANCES FOR FORMED SURFACES CONCRETE IN BUILDINGS**				
VARIATION FROM	**VARIATION IN**	**FOR ANY 10-FOOT LENGTH**	**FOR ANY 20-FOOT LENGTH OR ANY BAY**	**MAXIMUM FOR ENTIRE DIMENSION**
PLUMB OR SPECIFIED BATTER	LINES AND SURFACES OF COLUMNS, PIERS, WALLS AND ARRISES	1/4"	---	1"
	EXPOSED CORNER COLUMNS, CONTROL JOINT GROOVES, AND OTHER CONSPICUOUS LINES	---	1/4"	1/2"
LEVEL OR SPECIFIED GRADE	SLAB SOFFITS, CEILINGS, BEAM SOFFITS, AND ARRISES (MEASURED BEFORE REMOVAL OF SHORES)	1/4"	3/8"	3/4"
	EXPOSED LINTELS, SILLS, PARAPETS, HORIZONTAL GROOVES AND OTHER CONSPICUOUS LINES	---	1/4"	1/2"

TOLERANCES FOR FORMED SURFACES CONCRETE IN BUILDINGS**				
VARIATION FROM	**VARIATION IN**	**FOR ANY 10-FOOT LENGTH**	**FOR ANY 20-FOOT LENGTH OR ANY BAY**	**MAXIMUM FOR ENTIRE DIMENSION**
DRAWING DIMENSIONS	POSITION OF LINEAR BUILDING LINES, COLUMNS, WALLS, AND PARTITIONS	---	1/2"	1"
	SIZE AND LOCATION OF SLEEVES, FLOOR OPENINGS AND WALL OPENINGS	---	---	±1/4"
	CROSS SECTION OF COLUMNS, BEAMS, SLABS, AND WALLS	---	---	+1/2", -1/4"
	FOOTINGS* IN PLAN	---	---	+2", -1/2"
	FOOTING MISPLACEMENT OR ECCENTRICITY IN DIRECTION OF ERROR (THE LESSER OF)	---	---	2% OF WIDTH OR 2"
	FOOTING THICKNESS DECREASE	---	---	5%
	FOOTING THICKNESS INCREASE	---	---	NO LIMIT
	STEP RISE IN FLIGHT OF STAIRS	---	---	±1/8"
	STEP TREAD IN FLIGHT OF STAIRS	---	---	±1/4"
	CONSECUTIVE STEP RISE	---	---	±1/16"
	CONSECUTIVE STEP TREAD	---	---	±1/8"

* Footing tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel, dowels, or embedded items.
** Includes water and wastewater process structures.

END OF SECTION

SECTION 03151
JOINTS IN CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Waterstops and similar joints in concrete structures intended to retain water or withstand hydrostatic pressure.

1.02 UNIT PRICES

A. No separate payment will be made for joints under this Section. Include payment in unit price for structural concrete.

B. Refer to Section 01270, Measurement and Payment for unit price procedures.

1.03 REFERENCES

A. ASTM A775 - Standard Specification for Epoxy-Coated Reinforcing Steel Bars.

B. ASTM C920 - Specification for Elastomeric Joint Sealants.

C. ASTM D412 - Test Methods for Rubber Properties in Tension.

D. ASTM D624 - Test Method for Rubber Property - Tear Resistance.

E. ASTM D638 - Test Method for Tensile Properties of Plastics.

F. ASTM D746 - Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.

G. ASTM D747 - Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.

H. ASTM D1056 - Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.

I. ASTM D 1752 - Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

J. ASTM D 2000 - Specification for Rubber Products in Automotive Applications.

K. ASTM D 2240 - Test Method for Rubber Property - Durometer Hardness.

L. ASTM D 2241 - Specification for PVC Tubing.

M. Federal Specification SS-S-210A - Sealing Compound, Preformed Plastic for Expansion Joints and Pipe Joints.

N. Federal Specification TT-S-0227E(3) Sealing Compound, Elastomeric Type, Multi-Component, for Caulking, Sealing, and Glazing Buildings and Other Structures.

1.04 DEFINITIONS

A. The following definitions refer to concrete joints in water-retaining structures. Unless otherwise indicated, all such joints shall have a waterstop or sealant groove to prevent water penetration at the joint.

B. Construction Joint: The joint or surface between two concrete pours, produced by placing fresh concrete in contact with a hardened concrete surface.

C. A bond breaker may or may not be used, as indicated.

D. Reinforcing steel is continuous through the joint, unless otherwise indicated.

E. Contraction Joint: A joint similar to a construction joint, but intended to accommodate concrete shrinkage and similar movement.

F. A bond breaker is always used.

G. Reinforcing steel is held back 4-1/2 inches from the joint surface, and sleeved dowels are used so pours can move apart, unless otherwise indicated.

H. Expansion Joint: A joint similar to a construction or contraction joint, but intended to accommodate both expansion and contraction.

I. Compressible joint filler is placed against the hardened concrete, to form and separate the second pour so pours can move together or apart.

J. A centerbulb waterstop and joint sealant are used to fill the gap, unless otherwise indicated.

K. Reinforcing steel is held back, and sleeved dowels are used to allow and control movement, unless otherwise indicated.

L. Control Joint: A groove cut or formed in the face of a single pour, producing a weaker plane more likely to crack; used in an attempt to control locations of normal shrinkage cracks.

1. Joint sealant is used to fill the groove.
2. Reinforcing steel is continuous, since the pour is monolithic.

1.05 SUBMITTALS

A. Submit under provisions of Section 01330, Submittal Procedures.

B. Product Data: Information sufficient to indicate compliance with Contract Documents, including manufacturer's descriptive literature and specifications.

C. Shop Drawings: Indicate type, size, and location of each joint in each structure, and installation details.

D. Samples: For extrusions, submit 6-inch lengths. For molded or fabricated items, submit whole items. Submit 6-inch beads for sealants and 6-inch square samples for coatings, on appropriate substrates.

E. Quality Control Submittals: Submit manufacturer's instructions and recommendations for storage, handling and installation including material safety data sheets, and, where specified, test reports certified by an independent testing laboratory or the manufacturer, and manufacturer's certification that products furnished comply with Contract Documents.

1.06 QUALITY ASSURANCE

A. Waterstop Inspection: Notify City Engineer to schedule inspection at least 24 hours prior to work involving waterstop installation.

B. Construction Joint Sealant: Prepare adhesion and cohesion test specimens, as specified, at intervals of 5 working days while sealants are being installed.

C. Sealant material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure in laboratory and field tests:

1. Prepare sealant specimen between 2 concrete blocks (1 inch by 2 inches by 3 inches); spacing between the blocks shall be 1 inch. Use coated spacers (2 inches by 1-1/2 inches by 1/2 inch) to ensure sealant cross-sections of 1/2 inch by 2 inches with a width of 1 inch.
2. Cast and cure sealant according to manufacturer's recommendations except that curing period shall be not less than 24 hours.
3. Following curing period, widen the gap between blocks to 1-1/2 inches. Use spacers to maintain this gap for 24 hours prior to inspection for failure.

D. Sealant Installer: A competent waterproofing specialty contractor, approved by sealant manufacturer, having a record of successful performance in similar installations. Before beginning work, sealant manufacturer's representative shall instruct installer's crew in proper method of application.

1.07 WARRANTY

A. Provide a written warranty covering entire sealant installation against faulty and incompatible materials and workmanship, and agreeing to repair or replace defective work at no additional cost to the City, for a period of 5 years.

1.08 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 EPA POTABLE CLASSIFICATION

A. All joint materials shall be materials that reach acceptability for use in potable water systems no later than 30 days after installation, as classified by the Environmental Protection Agency.

2.02 JOINT SEALANT

A. Material: Polyurethane polymer designed for bonding to concrete which is continuously submerged in water. Use no material with an unsatisfactory history of bond or durability when used in joints of liquid-retaining structures.

B. Sealant Properties at 73 degrees F, 50 percent relative humidity:

1. Work Life: 45 - 180 minutes
2. Time to Reach 20 Shore A Hardness (at 77 degrees F, 200 gr quantity): 24 hours, maximum
3. Ultimate Hardness (ASTM D 2240):20 - 45 Shore A.
4. Tensile Strength (ASTM D 412): 200 psi, minimum.
5. Ultimate Elongation (ASTM D 412): 400 percent, minimum.
6. Tear Resistance (Die C ASTM D 624): 75 pounds per inch of thickness, minimum.
7. Color: Light Gray.

C. Polyurethane Sealants for Waterstop Joints in Concrete:

1. Sealant: 2-part polyurethane; when cured, sealant shall meet or exceed ANSI/ASTM C 920 or Federal Specification TT-S-0227 E(3) for 2-part material.
2. Vertical and overhead horizontal joints: Use only "non-sag" compounds meeting ANSI/ASTM C 920, Class 25, Grade NS, or Federal Specification TT-S-0227 E(3), Type II, Class A.

3. Plane horizontal joints: Self-leveling compounds meeting ANSI/ASTM C 920, Class 25, Grade P, or Federal Specification TT-S-0227 E(3), Type I. For joints subject to either pedestrian or vehicular traffic, use a compound providing non-tracking characteristics and having a Shore A hardness range of 35 to 45.
4. Primer: Use only compatible materials manufactured or recommended for the application by the sealant manufacturer, in accordance with the printed instructions and recommendations of the sealant manufacturer.

D. Acceptable Products: Polymeric Systems Inc. "PSI-270"; Pacific Polymers "Elastothane 227R"; Sika Corporation "Sikaflex 2C", or equal acceptable to the City Engineer.

E. Sealants for non-waterstop joints: Sikaflex-1A polyurethane sealant or equal.

2.03 MISCELLANEOUS MATERIALS

A. Bearing Pad: ASTM D2000 neoprene, Grade 2 or 3, Type BC, tensile strength 1450 psi, 60 durometer hardness, unless otherwise indicated.

B. Neoprene Sponge: ASTM D1056, Type 2C3-E1 closed-cell expanded neoprene.

C. Preformed Joint Filler: ASTM D1752 Type I non-extruding type; neoprene sponge or polyurethane of firm texture, except as otherwise specified. Bituminous fiber type will not be permitted.

D. Control Joint Former: Continuous plastic insert strips with anchorage ribs located at the bottom and an enlarged upper portion that is readily removable without damage to the concrete, and is sized to form sealant groove. Size to extend to at least 1/4 slab depth.

E. Backing Rod: Extruded closed-cell polyethylene foam rod, compatible with joint sealant materials used, with a tensile strength not less than 40 psi, and compression deflection approximately 25 percent at 8 psi. Size: 1/8-inch larger in diameter than joint width, except use one-inch diameter rod for 3/4-inch wide joints.

F. Bond Breaker: "Super Bond Breaker" manufactured by Burke Company, San Mateo, California; "Select Cure CRB", manufactured by Select Products Co., Upland, California, or equal acceptable to the City Engineer. Bond breaker shall contain a fugitive dye so areas of application will be readily distinguishable.

G. PVC Tubing: ASTM D 2241, Schedule SDR 13.5.

2.04 RESILIENT WATERSTOP

A. Resilient waterstop, where called for on the Drawings, shall be either a bentonite or adhesive type material.

B. Bentonite Waterstop:

1. Material: 75 percent bentonite, mixed with butyl rubber-hydrocarbon containing less than 1.0 percent volatile matter, and free of asbestos fibers or asphaltics.
2. Manufacturer's rated temperature ranges: For application, 5 to 125 degrees F; in service, -40 to 212 degrees F.
3. Cross-sectional dimensions, unexpanded waterstop: One inch by 3/4 inch.
4. Provide with adhesive backing capable of producing excellent adhesion to concrete surfaces.

C. Adhesive Waterstop:

1. Adhesive waterstop shall be at least 2 inches in diameter and shall be Synko-Flex preformed plastic adhesive waterstop by Synko-Flex Products, Inc., or equal. The waterstop shall meet or exceed requirements of Federal Specification SS-S-210A.
2. The adhesive waterstop shall be supplied wrapped completely by a two part protective paper.

3. The adhesive waterstop material shall have independent laboratory tests verifying that the material seals joints in concrete against leakage when subjected to a minimum of 30 psi water pressure for at least 72 hours.
4. Primer, to be used on hardened concrete surfaces, shall be provided by the same manufacturer as the waterstop material.

PART 3 EXECUTION

3.01 INSTALLATION

A. Embed waterstops in concrete across joints as shown. Waterstops shall be continuous for the extent of the joint; make splices necessary to provide such continuity in accordance with manufacturer's instructions. Support and protect waterstops during construction operations; repair or replace waterstops damaged during construction.

3.02 JOINT CONSTRUCTION

A. Joint Location: Unless specifically noted otherwise, provide construction joints at 25-foot maximum spacing for concrete construction. Where joints are shown spaced greater than 40 feet apart, provide additional joints to maintain the 25-foot maximum spacing. Submit joint locations for review by the City Engineer.

B. Joint Preparation: Prepare surfaces in accordance with Section 03310, Structural Concrete. Unless otherwise indicated, bonding is required at horizontal concrete joints in walls.

C. Construction Joint Sealant:

1. In water-bearing floor slabs and elsewhere where indicated, provide construction joints with tapered grooves filled with construction joint sealant. Leave groove- forming material in place until time grooves are cleaned and filled with joint sealant. After removing groove forms, remove laitance and fins and sand-blast the grooves. Allow grooves to dry thoroughly, then blow out, immediately prime surfaces, place bond-breaker tape in bottom of groove and fill with construction joint sealant. Use no sealant without a primer. Completely fill sealant grooves. Thoroughly clean areas designated to receive sealant, as specified for tapered grooves, prior to sealant application.

2. Mix and install primer and sealant in accordance with manufacturer's printed instructions and recommendations. Do not coat sides of sealant groove with bond breaker, curing compound or other substance which would interfere with proper sealant bond. Allow at least 7 days for sealant to achieve final cure before filling structure with water.
3. Thoroughly and uniformly mix 2-part catalyst-cured material.
4. Remove and replace improperly cured sealants after the manufacturer's recommended curing time; thoroughly sandblast the groove to remove all traces of uncured or partially-cured sealant and primer, then re-prime and re-seal with specified sealant.

D. Resilient Waterstop:

1. Install resilient waterstop in accordance with manufacturer's instructions and recommendations except as otherwise indicated and specified.
2. When requested by the Project Manager, provide technical assistance by manufacturer's representative in the field at no additional cost to the City.
3. Use resilient waterstop only where complete confinement by concrete is provided; do not use in expansion or contraction joints.
4. Where resilient waterstop is used in combination with PVC waterstop, lap resilient waterstop over PVC waterstop a minimum of 6 inches and place in contact with the PVC waterstop. Where crossing PVC at right angles, melt PVC ribs to form a smooth joining surface.
5. At the free top of walls without connecting slabs, stop the resilient waterstop and grooves (where used) 6 inches from the top in vertical wall joints.
6. Bentonite Waterstop:
   a. Locate bentonite waterstop as near as possible to the center of the joint and extend continuous around the entire joint. Minimum distance from edge of waterstop to face of member: 5 inches.
   b. Where thickness of the concrete member to be placed on the bentonite waterstop is less than 12 inches, place waterstop in grooves at least 3/4 inch deep and 1-1/4 inches wide formed or ground into the concrete. Minimum distance from edge of waterstop placed in groove to face of member: 2.5 inches.

c. Do not place bentonite waterstop when waterstop material temperature is below 40 degrees F. Waterstop material may be warmed so that it remains above 40 degrees F during placement but means used to warm it shall in no way harm the material or its properties. Do not install waterstop where air temperature falls outside manufacturer's recommended range.

d. Place bentonite waterstop only on smooth and uniform surfaces; grind concrete smooth if necessary to produce satisfactory substrate, or bond waterstop to irregular surfaces using an epoxy grout which completely fills voids and irregularities beneath the waterstop material. Prior to installation, wire brush the concrete surface to remove laitance and other substances that may interfere with bonding of epoxy.

e. In addition to the adhesive backing provided with the waterstop, secure bentonite waterstop in place with concrete nails and washers at 12-inch maximum spacing.

7. Adhesive Waterstop:

a. Thoroughly clean the concrete surface on which the waterstop is to be placed with a wire brush and coat with primer.

b. If the surface is too rough to allow the waterstop to form a complete contact, grind to form an adequately smooth surface.

c. Install the waterstop with the top protective paper left in place. Overlap joints between strips a minimum of 1 inch and cover back over with the protective paper.

d. Do not remove protective paper until just before final formwork completion. Concrete shall be placed immediately. The time that the waterstop material is uncovered prior to concrete placement shall be minimized and shall not exceed 24 hours.

E. Control Joints:

1. Where indicated, form in slabs by sawcutting, preformed plastic inserts or other means acceptable to City Engineer. Minimum insert or sawcut: 1/4 slab depth.

2. Perform sawcutting during the curing period as soon as possible after concrete has reached its final set, has attained sufficient strength to support sawcutting operations without damage, and while it remains fully saturated.

3. Leave the removable portion of plastic inserts in place and protect sawcuts against damage and intrusion of foreign material until the end of the curing period and until concrete has dried sufficiently to allow sealant installation.
4. Sealant Installation: Blow foreign material from formed or sawcut space. Insert a foam backer rod to form a sealant depth equal to the width of the space but not less than 3/8 inch. Install sealant as specified elsewhere in the Contract Documents.

END OF SECTION

SECTION 03211
REINFORCING STEEL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Structural concrete reinforcement and grouting of reinforcement dowel bars into hardened concrete.

1.02 UNIT PRICES

A. No separate payment will be made for reinforcing steel or grouting that is part of the Work as bid. Include payment in unit price for structural concrete.

B. Measurement for reinforcing steel installed as extra work is on a per-pound basis.

C. Refer to Section 01270, Measurement and Payment for unit price procedures.

1.03 REFERENCES

A. ACI 315 - Details and Detailing of Concrete Reinforcement.

B. ACI 318 - Building Code Requirements for Reinforced Concrete.

C. ASTM A36 - Standard Specification for Structural Steel.

D. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.

E. ASTM A185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.

F. ASTM A497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.

G. ASTM A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

H. ASTM A675 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties.

I. ASTM A775/A 775M - Standard Specification for Epoxy-Coated Reinforcing Steel Bars.

J. ASTM C881 - Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

K. AWS D1.4 - Structural Welding Code - Reinforcing Steel.

L. WRI - Manual of Standard Practice for Welded Wire Fabric.

M. CRSI MSP-1 - Manual of Standard Practice.

1.04 SUBMITTALS

A. Conform to Section 01330, Submittal Procedures.

B. Shop Drawings:

1. Submit shop drawings detailing reinforcement fabrication, bar placement location, splices, spacing, bar designation, bar type, length, size, bending, number of bars, bar support type and other pertinent information, including dimensions. Provide sufficient detail for placement of reinforcement without use of Contract Drawings. Information shall correspond directly to data listed on bill of materials.
2. Use of reproductions of Contract Drawings by Contractor, Subcontractor, erector, fabricator or material supplier in preparation of shop drawings (or in lieu of preparation of shop drawings) signifies acceptance by that party of information shown thereon as correct, and acceptance of obligation to pay for any job expense, real or implied, arising due to errors that may occur thereon. Remove references to Design Engineer, including seals, when reproductions of Contract Drawings are used as shop drawings.
3. Detail shop drawings in accordance with ACI 315, Figure 6.
4. Submit shop drawings showing location of proposed additional construction joints as required under Section 03151, Joints in Concrete Structures, and obtain approval of City Engineer, prior to submitting reinforcing steel shop drawings.

C. Bill of Materials: Submit with shop drawings.

D. Product Data:

1. Mechanical Bar Splices: Submit manufacturer's technical literature, including specifications and installation instructions.

2. Epoxy grout proposed for anchoring reinforcing dowels to hardened concrete: Submit manufacturer's technical literature including recommended installation procedures.

E. Certificates:

1. Submit steel manufacturer's certificates of mill tests giving properties of steel proposed for use. List manufacturer's test number, heat number, chemical analysis, yield point, tensile strength and percentage of elongation. Identify proposed location of steel in work.
2. Foreign-manufactured reinforcing bars shall be tested for conformance to ASTM requirements by a certified independent testing laboratory located in United States. Certification from any other source is not acceptable. Submit test reports for review. Do not begin fabrication of reinforcement until material has been approved.

1.05 HANDLING AND STORAGE

A. Store steel reinforcement above ground on platforms, skids or other supports. Protect reinforcing from mechanical injury, surface deterioration and formation of excessive, loose or flaky rust caused by exposure to weather. Protect epoxy-coated reinforcing from formation of any amount of rust.

1.06 QUALITY ASSURANCE

A. Notify City Engineer at least 48 hours before concrete placement so that reinforcement may be inspected, and errors corrected, without delaying Work.

PART 2 PRODUCTS

2.01 MATERIAL

A. Reinforcing Bars: Deformed bars conforming to ASTM A615, grade as indicated on Drawings, except column spirals and those shown on Drawings to be smooth bars. Where grade is not shown on Drawings, use Grade 60.

B. Smooth Bars: Where indicated on Drawings, use smooth bars conforming to ASTM A36; ASTM A615, Grade 60; or ASTM A675, Grade 70.

C. Smooth Bars: Conform to ASTM A775/A775M.

D. Welded Wire Fabric:

1. Welded Smooth Wire Fabric: Conform to ASTM A185.
2. Welded Deformed Wire Fabric: Conform to ASTM A497.

3. Provide wire size, type and spacing as shown. Where type is not shown on Drawings, use welded smooth wire fabric.
4. Furnish welded wire fabric in flat sheets only.

E. Tie Wire: 16-1/2 gage or heavier annealed steel wire. Use plastic-coated tie wire with epoxy-coated reinforcing steel.

F. Bar Supports: Provide chairs, riser bars, ties and other accessories made of plastic or metal, except as otherwise specified. Use bar supports and accessories of sizes required to provide required concrete cover. Where concrete surfaces are exposed to weather, water or wastewater, provide plastic accessories only; do not use galvanized or plastic-tipped metal in such locations. Provide metal bar supports and accessories rated Class 1 or 2 conforming to CRSI MSP-1 Manual of Standard Practice. Use epoxy-coated bar supports with epoxy-coated reinforcing bars.

G. Slabs on Grade: Provide chairs with sheet metal bases or provide precast concrete bar supports 3 inches wide, 6 inches long, and thick enough to allow required cover. Embed tie wires in 3-inch by 6-inch side.

H. Mechanical Bar Splices:

1. Conform to ACI 318; use where indicated on Drawings.
   a. Compression splices shall develop ultimate stress of reinforcing bar.
   b. Tension splices shall develop 125 percent of minimum yield point stress of reinforcing bar.
2. Regardless of chemical composition of steel, any heat effect shall not adversely affect performance of reinforcing bar.

I. Welded Splices:

1. Provide welded splices where shown and where approved by the City Engineer. Welded splices of reinforcing steel shall develop a tensile strength exceeding 125 percent of the yield strength of the reinforcing bars connected.
2. Provide materials for welded splices conforming to AWS D1.4.

J. Epoxy Grout: High-strength rigid epoxy adhesive, conforming to ASTM C881, Type IV, manufactured for purpose of anchoring dowels into hardened concrete and the moisture condition, application temperature and orientation of the hole to be filled. Unless otherwise shown, depth of embedment shall be as required to develop the full tensile strength (125 percent of yield strength) of dowel, but not less than 12 diameters.

2.02 FABRICATION

A. Bending: Fabricate bars to shapes indicated on Drawings by cold bending. Bends shall conform to minimum bend diameters specified in ACI 318. Do not straighten or rebend bars.

B. Splices:

1. Locate splices as indicated on Drawings. Do not locate splices at other locations without approval of City Engineer. Use minimum number of splices located at points of minimum stress. Stagger splices in adjacent bars.
2. Length of lap splices: As shown on Drawings.
3. Prepare ends of bars at mechanical splices in accordance with splice manufacturer's requirements.

C. Construction Joints: Unless otherwise shown, continue reinforcing through construction joints.

D. Bar Fabrication Tolerances: Conform to tolerances listed in ACI 315, Figures 4 and 5.

E. Standard Hooks: Conform to the requirements of ACI 318.

F. Marking: Clearly mark bars with waterproof tags showing number of bars, size, mark, length and yield strength. Mark steel with same designation as member in which it occurs.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean reinforcement of scale, loose or flaky rust and other foreign material, including oil, mud or coating that will reduce bond to concrete.

3.02 INSTALLATION

A. Placement Tolerances: Place reinforcement within tolerances of Table 03211A at the end of this Section. Bend tie wire away from forms to maintain the specified concrete coverage.

B. Interferences: Maintain 2-inch clearance from embedded items. Where reinforcing interferes with location of other reinforcing steel, conduit or embedded items, bars may be moved within specified tolerances or one bar diameter, whichever is greater. Where greater movement of bars is required to avoid interference, notify City Engineer. Do not cut reinforcement to install inserts, conduit, mechanical openings or other items without approval of City Engineer.

C. Concrete Cover: Provide clear cover measured from reinforcement to face of concrete as listed in Table 03211B at the end of this Section, unless otherwise indicated on Drawings.

D. Placement in Forms: Use spacers, chairs, wire ties and other accessory items necessary to assemble, space and support reinforcing properly. Provide accessories of sufficient number, size and strength to prevent deflection or displacement of reinforcement due to construction loads or concrete placement. Use appropriate accessories to position and support bolts, anchors and other embedded items. Tie reinforcing bars at each intersection, and to accessories. Blocking reinforcement with concrete or masonry is prohibited.

E. Placement for Concrete on Ground: Support bar and wire reinforcement on chairs with sheet metal bases or precast concrete blocks spaced at approximately 3 feet on centers each way. Use minimum of one support for each 9 square feet. Tie supports to reinforcing bars and wires.

F. Splices:

1. Do not splice bars, except at locations indicated on Drawings or reviewed shop drawings, without approval of City Engineer.
2. Lap Splices: Unless otherwise shown or noted, Class B, conforming to ACI 318-89, Section 12.15.1. Tie securely with wire prior to concrete placement, to prevent displacement of splices during concrete placement.
3. Mechanical Bar Splices: Use only where indicated on Drawings or approved by the City Engineer. Install in accordance with manufacturer's instructions.
   a. Couplers located at a joint face shall be of a type which can be set either flush or recessed from the face as shown. Seal couplers prior to concrete placement to completely eliminate concrete or cement paste from entering.
   b. Couplers intended for future connections: Recess 1/2 inch minimum from concrete surface. After concrete is placed, plug coupler and fill recess with sealant to prevent contact with water or other corrosive materials.
   c. Unless noted otherwise, match mechanical coupler spacing and capacity to that shown for the adjacent reinforcing.

G. Construction Joints: Place reinforcing continuous through construction joints, unless noted otherwise.

H. Welded Wire Fabric: Install wire fabric in as long lengths as practicable. Unless otherwise indicated on Drawings, lap adjoining pieces at least 6 inches or one full mesh plus 2 inches, whichever is larger. Lace splices with wire. Do not make end laps midway between supporting beams, or directly over beams of continuous structures. Offset end laps in adjacent widths to prevent continuous laps. Conform to WRI - Manual of Standard Practice for Welded Wire Fabric.

I. Field Bending: Shape reinforcing bent during construction operations to conform to Drawings. Bars shall be cold-bent; do not heat bars. Closely inspect reinforcing for breaks. When reinforcing is damaged, replace, Cadweld, or otherwise repair, as directed by City Engineer. Do not bend reinforcement after it is embedded in concrete.

J. Field Cutting: Cut reinforcing bars by shearing or sawing. Do not cut bars with cutting torch.

K. Welding of reinforcing bars is prohibited, except where shown on Drawings.

3.03 GROUTING OF REINFORCING AND DOWEL BARS

A. Use epoxy grout for anchoring reinforcing and dowel steel to existing concrete in accordance with epoxy manufacturer's instructions. Drill hole not more than 1/4 inch larger than steel bar diameter (including height of deformations for deformed bars) in existing concrete. Just before installation of steel, blow hole clean of all debris using compressed air. Partially fill hole with epoxy, using enough epoxy so when steel bar is inserted, epoxy grout will completely fill hole around bar. Dip end of steel bar in epoxy and twist bar while inserting into partially-filled hole.

Table 03211A
REINFORCEMENT PLACEMENT TOLERANCES

PLACEMENT	TOLERANCE IN INCHES
Clear Distance -	
To formed soffit:	-1/4
To other formed surfaces:	±1/4
Minimum spacing between bars:	-1/4
Clear distance from unformed surface to top reinforcement -	
Members 8 inches deep or less:	±1/4
Members more than 8 inches deep but less than 24 inches deep:	-1/4, +1/2
Members 24 inches deep or greater:	-1/4, +1
Uniform spacing of bars (but the required number of bars shall not be reduced):	±2
Uniform spacing of stirrups and ties (but the required number of stirrups and ties shall not be reduced):	±1
Longitudinal locations of bends and ends of reinforcement -	
General:	±2
Discontinuous ends of members:	±1/2
Length of bar laps:	-1-1/2
Embedded length -	
For bar sizes No. 3 through 11:	-1
For bar sizes No. 14 and 18:	-2

Table 03211B
MINIMUM CONCRETE COVER FOR REINFORCEMENT

SURFACE	MINIMUM COVER IN INCHES
Slabs and Joists -	
Top and bottom bars for dry conditions -	
No. 14 and No. 18 bars:	1-1/2
No. 11 bars and smaller:	1
Formed concrete surfaces exposed to earth, water or weather; over, or in contact with, sewage; and for bottoms bearing on work mat, or slabs supporting earth cover -	
No. 5 bars and smaller:	1-1/2
No. 6 through No. 18 bars:	2
Beams and Columns -	
For dry conditions -	
Stirrups, spirals and ties:	1-1/2
Principal reinforcement:	2
Exposed to earth, water, sewage or weather -	
Stirrups and ties:	2
Principal reinforcement:	2-1/2
Walls -	
For dry conditions -	
No. 11 bars and smaller:	1
No. 14 and No. 18 bars:	1-1/2
Formed concrete surfaces exposed to earth, water, sewage or weather, or in contact with ground -	
Circular tanks with ring tension:	2
All others:	2
Footings and Base Slabs -	
At formed surfaces and bottoms bearing on concrete work mat:	2
At unformed surfaces and bottoms in contact with earth:	3
Over top of piles:	2
Top of footings -- same as slabs	

END OF SECTION

SECTION 03215
CONCRETE DOWELING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American National Standards Institute (ANSI).
2. ASTM International (ASTM):
   a. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
   b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
3. International Code Council (ICC):
   a. 2006 International Building Code (IBC).
   b. Evaluation Services Reports.
4. NSF International (NSF): 61, Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.

B. Special Inspection: As defined in the ICC IBC.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer’s catalog information.

B. Informational Submittals:

1. Manufacturer’s qualifications; include client name, address, contact person, phone number, project location, and description of work.
2. Manufacturer’s instructions for preparation, placement, drilling of holes, installation of anchors and adhesive, and handling of cartridges, nozzles, and equipment.

3. Manufacturer's written letter of certification identifying installer's qualifications to install products.
4. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: At least three similar projects with same products within last 3 years.
2. Installer: Trained and certified by manufacturer.

B. Regulatory Requirements: Adhesive shall be certified as meeting NSF 61 for use in potable water structures.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Container Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

B. Store adhesive components in accordance with manufacturer's written instructions.

C. Dispose of when:

1. Shelf life has expired.
2. Stored other than per manufacturer's instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

1. Approved by an ICC Evaluation Services Report for conformance to 2006 IBC requirements for doweling of steel reinforcing bars in cracked concrete.
2. Suitable for long-term loads as well as for wind and seismic loads.
3. Meet requirements of ASTM C881/C881M.
4. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.

5. Disposable, Self-Contained Cartridge System:
   a. Capable of dispensing both components in proper mixing ratio.
   b. Fit into manually or pneumatically operated caulking gun.
6. Mixed Adhesive: Nonsag, light paste consistency with ability to remain in a 1-inch diameter overhead drilled hole without runout.
7. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
8. Potable Water Structures: Adhesive shall be acceptable for use by NSF 61.
9. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; HIT-RE 500-SD or HIT-HY 200 Adhesive Anchors.
   b. Powers Fasteners, Brewster, NY; Power PE1000+ Epoxy Adhesive Anchor System (1/2-inch to 7/8-inch diameter anchors).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors.

B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.

C. Reinforcing Dowels: As specified in Section 03211, Reinforcing Steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling Equipment:

1. Drilling Hammers for Dowel Holes:
   a. Electric or pneumatic rotary type with medium or light impact.
   b. Hollow drills with flushing air systems are preferred.
2. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

B. Hole Diameter: Use drill bit diameter meeting ICC Evaluation Services Report requirements and as recommended by manufacturer.

C. Obstructions in Drill Path: When existing reinforcing steel is encountered during drilling, obtain Engineer approval for proposed fix.

D. Doweling:

1. Install per details shown on Drawings and in accordance with adhesive manufacturer’s instructions.

2. When using epoxy anchors, dowels may be prebent prior to installation to 15 degrees to align with other bars. Do not heat dowels to bend.
3. Bent Bar Dowels: Where edge distances are critical, and intersection with reinforcing steel is likely, drill hole at 10-degree angle or less and use prebent reinforcing bars.
4. If bars have fused epoxy coating and coating is damaged, recoat damaged area with epoxy.

E. Adhesive:

1. Install in accordance with manufacturer's instructions.
2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.

3.02 FIELD QUALITY CONTROL

A. Special Inspection:

1. Special inspection will be performed by the Special Inspector in accordance with ICC ESR requirements and as specified in Section 01451, Special Inspection, Observation, and Testing.
2. Continuous inspection required where noted on Drawings and where concrete dowels are installed in overhead applications.
3. Periodic inspection required where continuous inspection is not specified.

END OF SECTION

SECTION 03310
STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cast-in-place normal-weight structural concrete.

1.02 UNIT PRICES

A. Measurement for structural concrete is on lump-sum basis for each structure as bid. Payment includes related work performed on these structures in accordance with related sections of these Specifications.

B. Measurement for extra structural concrete is on cubic-yard basis. Payment includes related work performed in accordance with related sections.

C. Refer to Section 01270, Measurement and Payment for unit price procedures.

1.03 REFERENCES

A. ACI 301 - Specifications for Structural Concrete for Buildings.

B. ACI 304.2R - Placing Concrete by Pumping Methods.

C. ACI 305.1 – Specification for Hot Weather Concreting.

D. ACI 306.1 - Standard Specification for Cold Weather Concreting.

E. ACI 309R - Guide for Consolidation of Concrete.

F. ACI 318 - Building Code Requirements for Reinforced Concrete.

G. ACI 350R - Environmental Engineering Concrete Structures.

H. ASTM C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.

I. ASTM C 33 - Standard Specification for Concrete Aggregates.

J. ASTM C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

K. ASTM C 42 - Standard Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

L. ASTM C 88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

M. ASTM C 94 - Standard Specifications for Ready-Mixed Concrete.

N. ASTM C 127 - Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.

O. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

P. ASTM C 136 - Sieve Analyses of Fine and Coarse Aggregates.

Q. ASTM C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.

R. ASTM C 150 - Standard Specification for Portland Cement.

S. ASTM C 157 - Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete.

T. ASTM C 172 - Standard Practice for Sampling Freshly Mixed Concrete.

U. ASTM C 173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.

V. ASTM C 192 - Method of Making and Curing Concrete Test Specimens in the Laboratory.

W. ASTM C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

X. ASTM C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.

Y. ASTM C 330 - Standard Specification for Lightweight Aggregates for Structural Concrete.

Z. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

AA. ASTM C 535 - Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

AB. ASTM C 567 - Standard Test Method for Unit Weight of Structural Lightweight Concrete.

AC. ASTM C 1064 - Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.

AD. Concrete Plant Manufacturer's Bureau (CPMB), Plant Mixer Manufacturers Division: Concrete Plant Mixer Standards.

AE. National Ready-Mixed Concrete Association (NRMCA): Certification of Ready-Mixed Concrete Production Facilities (checklist with instructions).

AF. John Wiley and Sons, Interscience Publishers Division, "Encyclopedia of Industrial Chemical Analysis," Vol. 15, Page 230 (alkalinity test procedure).

1.04 DEFINITIONS

A. Hot Weather: Any combination of high air temperature, low relative humidity and wind velocity tending to impair quality of fresh or hardened concrete or otherwise resulting in abnormal properties.

B. Cold Weather: Period when, for more than 2 successive days, mean daily temperature is below 40 degrees F.

1.05 SUBMITTALS

A. Conform to Section 01330, Submittal Procedures.

B. Mill Certificates: Required for bulk cement.

C. Design Mixes:

1. Submit test data on proposed design mixes for each type of concrete in the Work, including each class, and variations in type, source or quantity of material. Include type, brand and amount of cementitious materials; type, brand and amount of each admixture; slump; air content; aggregate sources, gradations, specific gravity and absorption; total water (including moisture in aggregate); water/cement ratio; compressive strength test results for 7 and 28 days; and shrinkage tests for Class C and D concrete at 21 or 28 days of drying.
2. Submit abrasion loss and soundness test results for limestone aggregate.

3. Testing of aggregates, including sieve analysis, shall be performed by a certified independent testing laboratory. Tests shall have been performed no earlier than 3 months before Notice to Proceed.
4. Provide standard deviation data for plant producing concrete. Data shall include copies of laboratory test results and standard deviation calculated in accordance with ACI 318, Item 5.3.1. Laboratory tests shall have been performed within past 12 months. When standard deviation data is not available, comply with ACI 318, Table 5.3.2.2.
5. Review and acceptance of mix design does not relieve Contractor of responsibility to provide concrete of quality and strength required by these Specifications.

D. Admixtures: Submit manufacturer's technical information, including following:

1. Air-Entraining Admixture: Give requirements to control air content under all conditions, including temperature variations and presence of other admixtures.
2. Chemical Admixtures: Give requirements for quantities and types to be used under various temperatures and job conditions to produce uniform, workable concrete mix. Submit evidence of compatibility with other admixtures and cementitious materials proposed for use in design mix.

E. High-range Water Reducer (Superplasticizer): When proposed for use, submit manufacturer's technical information and instructions for use of superplasticizer. State whether superplasticizer will be added at ready-mix plant or jobsite. When superplasticizer will be added at job site, submit proposed plan for measuring and adding superplasticizer to concrete mix at jobsite, and establish dosing area on site with holding tanks and metering devices. When superplasticizer is to be added at ready-mix plant, submit contingency plans for adding additional superplasticizer at jobsite when required due to delay in placing concrete. Identify portions of Work on which superplasticizer is proposed for use.

F. Hot and Cold Weather Concreting: Submit, when applicable, proposed plans for hot and cold weather concreting. Review and acceptance of proposed procedure will not relieve Contractor of responsibility for quality of finished product.

G. Project Record Drawings: Accurately record actual locations of embedded utilities and components which are concealed from view.

1.06 QUALITY ASSURANCE

A. Provide necessary controls during evaluation of materials, mix designs, production and delivery of concrete, placement and compaction to assure that the Work will be accomplished in accordance with Contract Documents. Maintain records of concrete placement. Record dates, locations, quantities, air temperatures, and test samples taken.

B. Code Requirements: Concrete construction for buildings shall conform to ACI 318. Concrete construction for water and wastewater treatment and conveying structures shall conform to ACI 318 with modifications by ACI 350R, Item 2.6. Where this Specification conflicts with ACI 318 or ACI 350R, this Specification governs.

C. Testing and Other Quality Control Services:

1. Concrete testing required in this section, except concrete mix design, limestone aggregate test data, and testing of deficient concrete, will be performed by an independent commercial testing laboratory employed and paid by the City in accordance with Section 01454, Testing Laboratory Services.
2. Provide material for and cooperate fully with City's testing laboratory technician in obtaining samples for required tests.
3. Standard Services: The following testing and quality control services will be provided by City in accordance with Section 01454, Testing Laboratory Services:
   a. Verification that plant equipment and facilities conform to NRMCA "Certification of Ready-Mix Concrete Production Facilities".
   b. Testing of proposed materials for compliance with this Specification.
   c. Review of proposed mix design submitted by Contractor.
   d. Obtaining production samples of materials at plants or stockpiles during work progress and testing for compliance with this Specification.
   e. Strength testing of concrete according to following procedures:
      1) Obtaining samples for field test cylinders from every 100 cubic yards and any portion less than 100 cubic yards for each mix design placed each day, according to ASTM C172, with each sample obtained from a different batch of concrete on a representative, random basis. Selecting test batches by any means other than random numbers chosen before concrete placement begins is not allowed.

2) Molding four specimens from each sample according to ASTM C31, and curing under standard moisture and temperature conditions as specified in Sections 7(a) and (b) of ASTM C31.
3) Testing two specimens at 7 days and two specimens at 28 days according to ASTM C39, reporting test results averaging strengths of two specimens. However, when one specimen evidences improper sampling, molding or testing, it will be discarded and remaining cylinder considered test result. When high-early-strength concrete is used, specimens will be tested at 3 and 7 days.

f. Air content: For each strength test, determination of air content of normal weight concrete according to ASTM C231.
g. Slump: For each strength test, and whenever consistency of concrete appears to vary, conducting slump test in accordance with ASTM C143.
h. Temperature: For each strength test, checking concrete temperature in accordance with ASTM C1064.
i. Monitoring of current and forecasted climatic conditions to determine when rate of evaporation, as determined by Figure 2.1.5 of ACI 305R, will produce loss of 0.2 pounds of water, or more, per square foot per hour. Testing lab representative will advise Contractor to use hot weather precautions when such conditions will exist during concrete placement, and note on concrete test reports when Contractor has been advised that hot weather conditions will exist.

4. Additional Testing and Quality Control Services: The following will be performed by an independent commercial testing laboratory employed and paid by the City in accordance with Section 01454, Testing Laboratory Services, when requested by City Engineer.
   a. Checking of batching and mixing operations.
   b. Review of manufacturer's report of each cement shipment and conducting laboratory tests of cement Molding and testing reserve 7-day cylinders or field cylinders.
   c. Conducting additional field tests for slump, concrete temperature and ambient temperature.
5. Contractor shall provide the following testing and quality control services:
   a. Employ an independent commercial testing laboratory, acceptable to City, to prepare and test design mix for each class of concrete for which material source has been changed.
   b. Notify commercial testing laboratory employed by City 24 hours prior to placing concrete.

6. Testing of deficient concrete in place:
   a. When averages of three consecutive strength test results fail to equal or exceed specified strength, or when any individual strength test result falls below specified strength by more than 500 psi, strength of concrete shall be considered potentially deficient and core testing, structural analysis or load testing may be required by Project Manager.
   b. When concrete in place proves to be deficient, Contractor shall pay costs, including costs due to delays, incurred in providing additional testing and analysis services provided by the City Engineer, or the independent commercial testing laboratory selected by the City.
   c. Replace concrete work judged inadequate by core tests, structural analysis or load tests at no additional cost to the City.
   d. Core Tests:
      1) Obtain and test cores in accordance with ASTM C42. Where concrete in structure will be dry under service conditions, air dry cores (temperature 60 to 80 degrees F, relative humidity less than 60 percent) for 7 days before test; test dry. Where concrete in structure will be more than superficially wet under service conditions, test cores after moisture conditioning in accordance with ASTM C42.
      2) Take at least three representative cores from each member or area of concrete in place that is considered potentially deficient. Location of cores shall be determined by Project Manager so as to least impair strength of structure. When, before testing, one or more cores shows evidence of having been damaged during or after removal from structure, replace the damaged cores.
      3) Concrete in area represented by core test will be considered adequate when average strength of cores is equal to at least 85 percent of specified strength, and when no single core is less than 75 percent of specified strength.
      4) Patch core holes in accordance with Section 03350, Concrete Finishing.
   e. Structural Analysis: When core tests are inconclusive or impractical to obtain, Project Manager may perform additional structural analysis at Contractor's expense to confirm safety of structure.
   f. Load Tests: When core tests and structural analysis do not confirm safety of structure, load tests may be required, and their results evaluated, in accordance with ACI 318.

g. Testing by impact hammer, sonoscope, probe penetration tests (Windsor probe), or other nondestructive device may be permitted by Project Manager to determine relative strengths at various locations in structure, to evaluate concrete strength in place, or for selecting areas to be cored. However, such tests, unless properly calibrated and correlated with other test data, shall not be used as basis for acceptance or rejection of structure's safety.

1.07 STORAGE AND HANDLING OF MATERIALS

A. Cement: Store cement in weathertight buildings, bins or silos to provide protection from dampness and contamination and to minimize warehouse set. When there is any doubt as to expansive potential of shrinkage-compensating cements because of method or length of storage and exposure, laboratory test cement before use.

B. Aggregate: Arrange and use aggregate stockpiles to avoid excessive segregation or contamination with other materials or with other sizes of like aggregates. Build stockpiles in successive horizontal layers not exceeding 3 feet in thickness. Complete each layer before next is started.

C. Fine Aggregate: Before using, allow fine aggregate to drain until uniform moisture content is reached.

D. Admixtures: Store admixtures to avoid contamination, evaporation or damage. For those used in form of suspensions or nonstable solutions, provide suitable agitating equipment to assure uniform distribution of ingredients. Protect liquid admixtures from freezing and other temperature changes which would adversely affect their characteristics.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement:

1. Use same brand of cement used in concrete mix design. Use only one brand of each type in each structure, unless otherwise indicated on Drawings.
2. Portland Cement: ASTM C150, Type I or Type II, gray in color. Use Type III only when specifically authorized by City Engineer in writing. Use Type II, including the requirements of Table 2, in construction of liquid-containing structures, unless shown otherwise on Drawings.

B. Admixtures:

1. Do not use calcium chloride, thiocyanate or admixtures containing more than 0.05 percent chloride ions.
2. Air-Entraining Admixtures: ASTM C260, compatible with other admixtures used.
3. Chemical Admixtures: Polymer type, nonstaining, chloride-free admixtures conforming to ASTM C494, Type A, C, D or E.
4. High-Range Water Reducer (Superplasticizer): ASTM C494, Type F or G, compatible with and by the same manufacturer as other admixtures.

C. Mixing Water: Use clean, potable water, free from harmful amounts of oils, acids, alkalis or other deleterious substances, meeting requirements of ASTM C94.

D. Aggregates: Use coarse aggregate from only one source, and fine aggregate from only one source, for exposed concrete in any single structure.

1. Coarse Aggregate: Gravel, crushed gravel or crushed limestone conforming to ASTM C33.
2. Fine Aggregate: Natural sand complying with ASTM C33.
3. Limestone aggregate shall conform to ASTM C33 and the following additional requirements: Clean, hard, strong and durable particles free of chemicals and coatings of silt, clay, or other fine materials that may affect hydration and bond of cement paste. Select crushed limestone: High-calcium limestone (minimum 95 percent $CaCO_3$ and maximum 3.5 percent $MgCO_3$) with maximum Los Angeles Abrasion loss of 38 percent, when tested in accordance with ASTM C131 or ASTM C535. Test aggregate for soundness in accordance with ASTM C88; maximum loss shall not exceed 18 percent after 5 cycles of magnesium sulfate test.
4. Maximum size of coarse aggregate:
   a. Normal weight concrete, except as noted below: 1-1/2 inches.
   b. Formed members 6 inches or less in least dimension: 1/5 least dimension.
   c. Slabs: 1/3 depth of slab.
   d. Drilled shafts: 1/3 clearance between reinforcing steel, but not greater than 3/4 inch.
   e. Concrete fill, seal slabs and bonded concrete topping in clarifiers: 3/8 inch.

E. Calcium Chloride: Not permitted.

F. Evaporation Retardant: Masterbuilders "Confilm", Euclid "Eucobar", or equal.

G. Miscellaneous Materials:

1. Bonding Agent: Two-component modified epoxy resin.
2. Non-shrink grout: As specified in Section 03600, Structural Grout.

2.02 CONCRETE MIX

A. Objective: Select proportions of ingredients to produce concrete having proper placability, durability, strength, appearance, and other specified properties.

B. Mix Design: Employ and pay an independent commercial testing laboratory, acceptable to City, to prepare and test mix designs for each type of concrete specified. Proportion mix design ingredients by weight. Submit mix designs and test results for approval.

1. During the trial batches, aggregate proportions may be adjusted by the testing laboratory using two coarse aggregate size ranges to obtain the required properties. If one size range produces an acceptable mix, a second size range need not be used. Such adjustments shall be considered refinements to the mix design and shall not be the basis for extra compensation to the Contractor. Concrete shall conform to the requirements of this Section, whether the aggregate proportions are from the Contractor's preliminary mix design, or whether the proportions have been adjusted during the trial batch process. Prepare trial batches using the aggregates, cement and admixtures proposed for the project. Make trial batches large enough to obtain 3 drying shrinkage test specimens and 6 compression test specimens from each batch.
2. Determine compressive strength by testing 6-inch diameter by 12-inch high cylinders, made, cured and tested in accordance with ASTM C192 and ASTM C39. Test 3 compression test cylinders at 7 days and 3 at 28 days. Average compressive strength for the 3 cylinders tested at 28 days for any given trial batch shall be not less than 125 percent of the specified compressive strength.
3. Perform sieve analysis of the combined aggregate for each trial batch according to of ASTM C136. Report percentage passing each sieve.
4. In mix designs for Class A and D concrete, fine aggregate shall not exceed 41 percent of total aggregate by weight.

C. Selecting Ingredient Proportions for Concrete:

1. Proportion concrete mix according to ACI 301, Chapter 3.
2. Establish concrete mix design by laboratory trial batches prepared by independent testing laboratory, or on basis of previous field experience in accordance with provisions of ACI 318, Item 5.3; however, minimum cement content for each class of concrete shall not be less than specified.

3. Concrete mix design data submitted for review shall have average 28-day compressive strength calculated in accordance with ACI 318, Item 5.3.2.1. When data is not available to determine standard deviation in accordance with ACI 318, Item 5.3.1, average 28-day strength of mix design shall conform to ACI 318, Table 5.3.2.2.

D. Water-Cement Ratios:

1. Maximum allowable water-cement ratios shall be as follows:
   a. Concrete for liquid-containing structures: 0.45.
   b. All other concrete: 0.55.
2. Superplasticizer may be added to maintain specified maximum water-cement ratios. Include free water in aggregate in water-cement ratio computations.

E. Adjustment of Mix Proportions: After sufficient data becomes available during construction, mix may be adjusted upon approval of Project Manager, in accordance with ACI 318, Item 5.5; however, minimum cement content for each class of concrete shall not be less than specified.

F. Entrained Air: Air-entrain all concrete except drilled shafts. Total air content in accordance with ASTM C173: 4 to 6 percent.

G. Consistency, Workability, and Slump:

1. The quantity of water in a batch of concrete shall be just sufficient, with a normal mixing period, to produce concrete which can be worked properly into place without segregation, and which can be compacted by vibratory methods as specified, to give the desired strength, density, impermeability and smoothness of surface. Change the quantity of water as necessary, with variations in the nature or moisture content of the aggregates, to maintain uniform production of a desired consistency. Determine the consistency of the concrete in successive batches by slump tests in accordance with ASTM C 143. Slumps shall be as follows:

Concrete Type	Minimum Slump	Maximum Slump
Portland Cement Concrete:	2"	4"
Concrete to be dosed with superplasticizer:	1"	3"
Normal Weight Concrete after dosing with superplasticizer:	4"	9"

2. Specified slump shall apply at time when concrete is discharged at job site. Perform slump tests to monitor uniformity and consistency of concrete delivered to job site; however, do not use as basis for mix design. Do not exceed water-cement ratios specified.

H. Admixtures: Proportion admixtures according to manufacturer's recommendations. Use of accelerator is permitted when air temperature is less than 40 degrees F. Use of retarder is permitted when temperature of placed concrete exceeds 65 degrees F.

I. High-Range Water Reducers (Superplasticizers): Use superplasticizer to improve workability of concrete or delay hydration of cement, in accordance with requirements and recommendations of product manufacturer and approved submittals.

J. Concrete Classification and Strength:

1. Strength: Conform to values for class of concrete indicated on Drawings for each portion of Work. Requirements are based on 28-day compressive strength. If high early-strength concrete is allowed, requirements are based on 7-day compressive strength.
2. Classification:

Class (Normal-weight)	Minimum 28-Day Compressive Strength (psi)	Minimum Cement Content Pounds per Cubic Yard
Concrete for Structures Containing Water or Wastewater		
A	4000	564 (6 Sacks)
B	1500	329 (3-1/2 Sacks)
C	3000	470 (5 Sacks)
D	5000	658 (7 Sacks)
H	3000	611 (6-1/2 Sacks)
Concrete for Buildings, Slabs on Grade and Miscellaneous Structures		
AB	4000	Not Applicable
BB	1500	Not Applicable
CB	3000	Not Applicable
DB	5000	Not Applicable

3. Maximum size aggregate for Class H concrete: 3/8 inch. Maximum size aggregate for all other normal-weight concrete: 1-1/2 inches, except as specified in Paragraph 2.01D.4.
4. When required strength is not obtained with minimum cement content as specified, add cement, lower water-cement ratio or provide other aggregates as necessary.

K. Use of Classes of Concrete:

1. Use classes of concrete as indicated on the Drawings and in other specifications.
2. Liquid-containing structures: If not otherwise indicated, use the following classes for structures containing water or wastewater and for utility applications in the locations described:
   a. Class A: All reinforced concrete and where not otherwise defined.
   b. Class B: Unreinforced concrete used for plugging pipes, seal slabs, thrust blocks and trench dams, unless indicated otherwise.
   c. Class H: Fill and topping. Where concrete fill thickness exceeds 3 inches in the majority of a placement and is not less than 1.5 inches thick, Class A concrete may be used.
3. All other structures: If not otherwise indicated, use the following classes in the locations described:
   a. Class AB: All reinforced concrete and where not otherwise defined.
   b. Class CB: Duct banks; see Section 16402, Underground Duct Banks for additional requirements.
   c. Class BB: Unreinforced concrete fill under structures.

2.03 MIXING NORMAL WEIGHT CONCRETE

A. Conform to ACI 301, Chapter 7.

B. Ready-Mixed Concrete:

1. Measure, batch, mix and transport ready-mixed concrete according to ASTM C94. Plant equipment and facilities shall conform to NRMCA "Certification of Ready Mixed Concrete Production Facilities".
2. Provide batch tickets with information specified in ASTM C94. Deliver batch ticket with concrete and give to City's on-site testing laboratory representative.

C. Batch Mixing at Site:

1. Mix concrete in batch mixer conforming to requirements of CPMB "Concrete Plant Mixer Standards". Use mixer equipped with suitable charging hopper, water storage tank and water measuring device. Batch mixer shall be capable of mixing aggregates, cement and water into uniform mass within specified mixing time, and of discharging mix without segregation. Operate mixer according to rated capacity and recommended revolutions per minute printed on manufacturer's rating plate.

2. Charge batch into mixer so some water will enter before cement and aggregates. Keep water running until one-fourth of specified mixing time has elapsed. Provide controls to prevent discharging until required mixing time has elapsed. When concrete of normal weight is specified, provide controls to prevent addition of water during mixing. Discharge entire batch before mixer is recharged.
3. Mix each batch of 2 cubic yards or less for not less than 1 minute and 30 seconds. Increase minimum mixing time 15 seconds for each additional cubic yard or fraction of cubic yard.
4. Keep mixer clean. Replace pick-up and throw-over blades in drum when they have lost 10 percent of original depth.

D. Admixtures:

1. Charge air-entraining and chemical admixtures into mixer as solution using automatic dispenser or similar metering device. Measure admixture to accuracy within plus or minus 3 percent. Do not use admixtures in powdered form.
2. Two or more admixtures may be used in same concrete, provided that admixtures in combination retain full efficiency and have no deleterious effect on concrete or on properties of each other. Inject admixtures separately during batching sequence.
3. Add retarding admixtures as soon as practicable after addition of cement.

E. Temperature Control:

1. When ambient temperature falls below 40 degrees F, keep as-mixed temperature above 55 degrees F to maintain concrete above minimum placing temperature.
2. When water or aggregate has been heated, combine water with aggregate in mixer before cement is added. Do not add cement to mixtures of water and aggregate when temperature of mixture is greater than 100 degrees F.
3. In hot weather, maintain temperature of concrete below maximum placing temperature. When necessary, temperature may be lowered by cooling ingredients, cooling mixer drum by fog spray, using chilled water or well-crushed ice in whole or part for added water, or arranging delivery sequence so that time of transport and placement does not generate unacceptable temperatures.
4. Submit hot weather and cold weather concreting plans for approval.

2.04 EQUIPMENT

A. Select equipment of size and design to ensure continuous flow of concrete at delivery end. Conform to following equipment and operations requirements.

B. Truck mixers, agitators and manner of operation: Conform to ASTM C94. Use of non-agitating equipment for transporting concrete is not permitted.

C. Belt conveyors: Configure horizontally, or at a slope causing no segregation or loss. Use approved arrangement at discharge end to prevent separation. Discharge long runs without separation into hopper.

D. Chutes: Metal or metal-lined (other than aluminum). Arrange for vertical-to-horizontal slopes not more than 1 to 2 nor less than 1 to 3. Chutes longer than 20 feet or not meeting slope requirements may be used if concrete is discharged into hopper before distribution.

E. Do not use aluminum or aluminum-alloy pipe or chutes for conveying concrete.

PART 3 EXECUTION

3.01 SPECIAL CONSIDERATIONS

A. Concreting Under Water: Not permitted except where shown otherwise on Drawings or approved by City Engineer. When shown or permitted, deposit concrete under water by methods acceptable to the City Engineer so fresh concrete enters mass of previously-placed concrete from within, causing water to be displaced with minimum disturbance at surface of concrete.

B. Protection from Adverse Weather: Unless adequate protection is provided or City Engineer's approval is obtained, do not place concrete during rain, sleet, snow or freezing weather. Do not permit rainwater to increase mixing water or to damage surface finish. If rainfall occurs after placing operations begin, provide adequate covering to protect Work.

3.02 PREPARATION OF SURFACES FOR CONCRETING

A. Earth Surfaces:

1. Under interior slabs on grade, install vapor barrier. Lap joints at least 6 inches and seal watertight with tape, or sealant applied between overlapping edges and ends. Repair vapor barrier damaged during placement of reinforcing and inserts with vapor barrier material; lap over damaged areas at least 6 inches and seal watertight.

2. Other Earth Surfaces: Thoroughly wet by sprinkling prior to placing concrete, and keep moist by frequent sprinkling up to time of placing concrete thereon. Remove standing water. Surfaces shall be free from standing water, mud and debris at the time of placing concrete.

B. Construction Joints:

1. Definition: Concrete surfaces upon or against which concrete is to be placed, where the placement of the concrete has been interrupted so that, in the judgment of the Project Manager, new concrete cannot be incorporated integrally with that previously placed.
2. Interruptions: When placing of concrete is to be interrupted long enough for the concrete to take a set, use forms or other means to shape the working face to secure proper union with subsequent work. Make construction joints only where acceptable to the Project Manager.
3. Preparation: Give horizontal joint surfaces a compacted, roughened surface for good bond. Except where the Drawings call for joint surfaces to be coated, clean joint surfaces of laitance, loose or defective concrete and foreign material by hydroblasting or sandblasting (exposing aggregate), roughen surface to expose aggregate to a depth of at least 1/4 inch and wash thoroughly. Remove standing water from the construction joint surface before new concrete is placed.
4. After surfaces have been prepared cover approximately horizontal construction joints with a 3-inch lift of a grout mix consisting of Class A concrete batched without coarse aggregate; place and spread grout uniformly. Place wall concrete on the grout mix immediately thereafter.

C. Set and secure reinforcement, anchor bolts, sleeves, inserts and similar embedded items in the forms where indicated on Contract Drawings, shop drawings and as otherwise required. Obtain Project Manager's acceptance before concrete is placed. Accuracy of placement is the sole responsibility of the Contractor.

D. Place no concrete until at least 4 hours after formwork, inserts, embedded items, reinforcement and surface preparation have been completed and accepted by the Project Manager. Clean surfaces of forms and embedded items that have become encrusted with grout or previously-placed concrete before placing adjacent concrete.

E. Casting New Concrete Against Old: Where concrete is to be cast against old concrete (any concrete which is greater than 60 days of age), thoroughly clean and roughen the surface of the old concrete by hydro-blasting or sandblasting (exposing aggregate). Coat joint surface with epoxy bonding agent following manufacturer's written instructions, unless indicated otherwise. Unless noted otherwise, this provision does not apply to vertical wall joints where waterstop is installed.

F. Protection from Water: Place no concrete in any structure until water entering the space to be filled with concrete has been properly cut off or diverted and carried out of the forms, clear of the work. Deposit no concrete underwater. Do not allow still water to rise on any concrete until concrete has attained its initial set. Do not allow water to flow over the surface of any concrete in a manner and at a velocity that will damage the surface finish of the concrete. Pumping, dewatering and other necessary operations for removing ground water, if required, are subject to Project Manager's review.

G. Corrosion Protection: Position and support pipe, conduit, dowels and other ferrous items to be embedded in concrete construction prior to placement of concrete so there is at least a 2-inch clearance between them and any part of the concrete reinforcement. Do not secure such items in position by wiring or welding them to the reinforcement.

H. Where practicable, provide for openings for pipes, inserts for pipe hangers and brackets, and setting of anchors during placing of concrete.

I. Accurately set anchor bolts and maintain in position with templates while they are being embedded in concrete.

J. Cleaning: Immediately before concrete is placed, thoroughly clean dirt, grease, grout, mortar, loose scale, rust and other foreign substances from surfaces of metalwork to be in contact with concrete.

3.03 HANDLING, TRANSPORTING AND PLACING CONCRETE

A. Conform to applicable requirements of Chapter 8 of ACI 301 and this Section. Use no aluminum materials in conveying concrete.

B. Rejected Work: Remove concrete found to be defective or non-conforming in materials or workmanship. Replace rejected concrete with concrete meeting requirements of Contract Documents, at no additional cost to the City.

C. Unauthorized Placement: Place no concrete except in the presence of the Project Manager. Notify the Project Manager in writing at least 24 hours before placement of concrete.

D. Placement in Wall Forms:

1. Do not drop concrete through reinforcing steel.
2. Do not place concrete in any form so as to leave an accumulation of mortar on form surfaces above the concrete.

3. Pump concrete or use hoppers and, if necessary, vertical ducts of canvas, rubber or metal (other than aluminum) for placing concrete in forms so it reaches the place of final deposit without separation. Free fall of concrete shall not exceed 4 feet below the ends of pump hoses, ducts, chutes or buggies. Uniformly distribute concrete during depositing.
4. Do not displace concrete in forms more than 6 feet in horizontal direction from place where it was originally deposited.
5. Deposit in uniform horizontal layers not deeper than 2 feet; take care to avoid inclined layers or inclined construction joints except where required for sloping members.
6. Place each layer while the previous layer is still soft. Rate of placement shall not exceed 5 feet of vertical rise per hour.
7. Provide sufficient illumination in form interior so concrete at places of deposit is visible from the deck or runway.

E. Conveyors and Chutes**:** Design and arrange ends of chutes, hopper gates and other points of concrete discharge in the conveying, hoisting and placing system so concrete passing from them will not fall separated into whatever receptacle immediately receives it. Conveyors, if used, shall be of a type acceptable to the City Engineer. Do not use chutes longer than 50 feet. Slope chutes so concrete of specified consistency will readily flow. If a conveyor is used, it shall be wiped clean by a device operated in such a manner that none of the mortar adhering to the belt will be wasted. All conveyors and chutes shall be covered.

F. Placement of Slabs**:** In hot or windy weather, conducive to plastic shrinkage cracks, apply evaporation retardant to slab after screeding in accordance with manufacturer's instructions and recommendations. Do not use evaporation retardant to increase water content of the surface cement paste. Place concrete for sloping slabs uniformly from the bottom of the slab to the top, for the full width of the placement. As work progresses, vibrate and carefully work concrete around slab reinforcement. Screed the slab surface in an up-slope direction.

G. Concrete Temperature: When placed, not more than 90 degrees F nor less than 55 degrees F for sections less than 12 inches thick, nor less than 50 degrees for all other sections. Do not heat concrete ingredients to a temperature higher than that necessary to keep the temperature of the mixed concrete, as placed, from falling below the specified minimum temperature. When concrete temperature is 85 degrees F or above, do not exceed 60 minutes between introduction of cement to the aggregates and discharge. When the weather is such that the concrete temperature would exceed 90 degrees F, employ effective means, such as pre-cooling of aggregates and mixing water, using ice or placing at night, as necessary to maintain concrete temperature, as placed, below 90 degrees F.

H. Cold Weather Placement: Conform to ACI 306.1 - Standard Specification for Cold Weather Concreting, and the following.

1. Remove snow, ice and frost from surfaces, including reinforcement, against which concrete is to be placed. Before beginning concrete placement, thaw the subgrade to a minimum depth of 6 inches. Warm reinforcement and embedded items to above 32 degrees F prior to concrete placement.
2. Maintain concrete temperature above 50 degrees F for at least 3 days after placement.

3.04 PUMPING OF CONCRETE

A. If pumped concrete does not produce satisfactory results, in the judgment of the Project Manager, discontinue pumping operations and proceed with the placing of concrete using conventional methods.

B. Pumping Equipment**:** Use a 2-cylinder pump designed to operate with only one cylinder if one is not functioning, or have a standby pump on site during pumping.

C. The minimum hose (conduit) diameter: Comply with ACI 304.2R.

D. Replace pumping equipment and hoses (conduits) that do not function properly.

E. Do not use aluminum conduits for conveying concrete.

F. Field Control**:** Take samples for slump, air content and test cylinders at the placement (discharge) end of the line.

3.05 CONCRETE PLACEMENT SEQUENCE

A. Place concrete in a sequence acceptable to the Project Manager. To minimize effects of shrinkage, place concrete in units bounded by construction joints shown. Place alternate units so each unit placed has cured at least 7 days for hydraulic structures, or 3 days for other structures, before contiguous unit or units are placed, except do not place corner sections of vertical walls until the 2 adjacent wall panels have cured at least 14 days for hydraulic structures and 7 days for other structures.

B. Level the concrete surface whenever a run of concrete is stopped. To ensure straight and level joints on the exposed surface of walls, tack a wood strip at least 3/4-inch thick to the forms on these surfaces. Carry concrete about 1/2 inch above the underside of the strip. About one hour after concrete is placed, remove the strip, level irregularities in the edge formed by the strip with a trowel and remove laitance.

3.06 TAMPING AND VIBRATING

A. Thoroughly settle and compact concrete throughout the entire depth of the layer being consolidated, into a dense, homogeneous mass; fill corners and angles, thoroughly embed reinforcement, eliminate rock pockets and bring only a slight excess of water to the exposed surface of concrete during placement. Use ACI 309R Group 3 immersion-type high-speed power vibrators (8,000 to 12,000 rpm) in sufficient number and with sufficient (at least one) standby units. Use Group 2 vibrators only when accepted by the City Engineer for specific locations.

B. Use care in placing concrete around waterstops. Carefully work concrete by rodding and vibrating to make sure air and rock pockets have been eliminated. Where flat-strip type waterstops are placed horizontally, work concrete under waterstops by hand, making sure air and rock pockets have been eliminated. Give concrete surrounding the waterstops additional vibration beyond that used for adjacent concrete placement to assure complete embedment of waterstops in concrete.

C. Concrete in Walls: Internally vibrate, ram, stir, or work with suitable appliances, tamping bars, shovels or forked tools until concrete completely fills forms or excavations and closes snugly against all surfaces. Do not place subsequent layers of concrete until previously-placed layers have been so worked. Provide vibrators in sufficient numbers, with standby units as required, to accomplish the results specified within 15 minutes after concrete of specified consistency is placed in the forms. Keep vibrating heads from contact with form surfaces. Take care not to vibrate concrete excessively or to work it in any manner that causes segregation of its constituents.

3.07 REPAIRING SURFACE DEFECTS AND FINISHING

A. Conform to Section 03350, Concrete Finishing.

3.08 CURING

A. Conform to Section 03390, Concrete Curing.

3.09 LIQUID TIGHTNESS TEST

A. Purpose: To determine integrity and liquid-tightness of finished exterior and interior concrete surfaces of liquid containment structures.

B. Test the following structures for liquid-tightness: The RAS Facility new walls and the new wall at the Scum Pump Station.

C. Water for initial tightness test will be provided by Owner.

1. Water source will be non-potable water (NPW).
2. Provide means to transport water to structure to be tested.
3. If additional tightness tests are required because of failure to meet criteria, provide water for subsequent tests.

D. After testing has been completed, discharge water into the yard piping drain.

E. Liquid-Tightness Test Requirement:

1. Perform tightness tests in accordance with ACI 350.1 and as specified herein.
2. Do not place backfill, grout topping slab, coatings, or other work that will cover concrete surfaces until tightness testing has been completed and approved.
3. Visually observe conditions of new concrete walls to detect leakage at joints or through cracks or defective areas.
4. Acceptance Criteria:
   a. No visible leaks or seepage are present.
   b. No damp spots are present such that moisture can be picked up by a dry hand.
5. Repairs When Test Fails:
   a. Dewater structure; fill leaking cracks by crack injection as specified in Section 03740, Crack Repair Injection Grouting.
   b. Patch areas of damp spots previously recorded, and repeat water leakage test in its entirety until structure successfully passes test.

3.10 PROTECTION

A. Protect concrete against damage until final acceptance by the City.

B. Protect fresh concrete from damage due to rain, hail, sleet or snow. Provide such protection while the concrete is still plastic and whenever such precipitation is imminent or occurring.

C. Do not backfill around concrete structures or subject them to design loadings until all components of the structure needed to resist the loading are complete and have reached the specified 28-day compressive strength, except as authorized otherwise by the City Engineer.

END OF SECTION

SECTION 03350
CONCRETE FINISHING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Repairing surface defects.

B. Finishing concrete surfaces including both formed and unformed surfaces.

C. Sealing concrete surfaces.

1.02 UNIT PRICES

A. No separate payment will be made for concrete finishing under this Section. Include payment in unit price for structural concrete.

1.03 REFERENCES

A. ASTM C144 - Standard Specification for Aggregate for Masonry Mortar.

B. ASTM C 881 - Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

C. ASTM C1059 - Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.

D. ASTM D4587 - Conducting Tests on Paint and Related Coatings and Materials Using a Fluorescent UV-Condensation Light-and Water-Exposure Apparatus.

E. ASTM E1155 - Standard Test Method for Determining Floor Flatness and Levelness Using the F Number System.

1.04 SUBMITTALS

A. Conform to Section 01330 - Submittal Procedures.

B. Submit manufacturer's technical literature on the following products proposed for use. Include manufacturer's installation and application instructions and, where specified, manufacturer's certification of conformance to requirements and suitability for use in the applications indicated.

1. Sealer.
2. Latex bonding agent.

3. Epoxy adhesive.
4. Evaporation retardant.

PART 2 PRODUCTS

2.01 MATERIALS

A. Sealer/Dustproofer (VOC Compliant): Water-based acrylic sealer; non-yellowing under ultraviolet light after 200-hour test in accordance with ASTM D4587. Conform to local, state and federal solvent emission requirements.

B. Latex Bonding Agent: Non-redispersable latex base liquid conforming to ASTM C1059. When used in water and wastewater treatment structures, bonding agent shall be suitable for use under continuously submerged conditions. Conformance and suitability certification by manufacturer is required.

C. Bonding Grout: Prepare bonding grout by mixing approximately one part cement to one part fine sand meeting ASTM C144 but with 100 percent passing No. 30 mesh sieve. Mix with water to consistency of thick cream. At Contractor's option, a commercially-prepared bonding agent used in accordance with manufacturer's recommendations and instructions may be used. When used in water and wastewater treatment structures, bonding agent shall be suitable for use under continuously submerged conditions. Conformance and suitability certification by manufacturer is required. Submit manufacturer's technical information on proposed bonding agent.

D. Patching Mortar:

1. Make patching mortar of same materials and of approximately same proportions as concrete, except omit coarse aggregate. Substitute white Portland cement for part of gray Portland cement on exposed concrete in order to match color of surrounding concrete. Determine color by making trial patch. Use minimum amount of mixing water required for handling and placing. Mix patching mortar in advance and allow to stand. Mix frequently with trowel until it has reached stiffest consistency that will permit placing. Do not add water.
2. Proprietary compounds for adhesion or specially formulated cementitious repair mortars may be used in lieu of or in addition to foregoing patching materials provided that properties of bond and compressive strength meet or exceed the foregoing and color of surrounding concrete can be matched where required. Use such compounds according to manufacturer's recommendations. When used in water and wastewater treatment structures, material shall be suitable for use under continuously submerged conditions. Conformance and suitability certification by manufacturer is required.

E. Epoxy Adhesive: Two-component, 100 percent solids, 100 percent reactive compound developing 100 percent of strength of concrete, suitable for use on dry or damp surfaces. Epoxy used to inject cracks and as a binder in epoxy mortar shall meet ASTM C881, Type VI. Epoxy used as a bonding agent for fresh concrete shall meet ASTM C881, Type V.

F. Non-shrink Grout: See Section 03600, Structural Grout.

G. Concrete Fill: Class H concrete with 3/8-inch maximum coarse aggregate size, (Class C where fill thickness exceeds 3 inches throughout a placement), as specified in Section 03310, Structural Concrete.

H. Evaporation Retardant: Confilm, manufactured by Master Builders; Eucobar, manufactured by Euclid Chemical Company; or equal.

PART 3 EXECUTION

3.01 AGGREGATE CONCEALMENT

A. Unless indicated otherwise on Drawings or approved by City Engineer, all surfaces to be finished shall be free of exposed aggregate.

3.02 REPAIRING SURFACE DEFECTS

A. Defective Areas: Repair immediately after removal of forms. Remove honeycombed and other defective concrete down to sound concrete but in no case to a depth less than one inch. Make edges of cuts perpendicular to concrete surface. Thoroughly work bonding grout into the surface with a brush as that the entire surface is covered. Alternatively, a proprietary bonding agent may be used. Use bonding agent in accordance with manufacturer's instructions. While bonding coat is still tacky, apply premixed patching mortar. Thoroughly consolidate mortar into place and strike off to leave patch slightly higher than surrounding surface. To permit initial shrinkage, leave undisturbed for at least 1 hour before final finishing. Keep patched area damp for 7 days. Alternatively, a proprietary cementitious repair mortar may be used and placed in accordance with manufacturer's instructions. Do not use metal tools in finishing patches in formed walls which will be exposed.

B. Tie Holes: Patch holes immediately after removal of forms. After cleaning and roughening with a wire brush on a rotary drill, thoroughly dampen tie hole and fill solid with patching mortar. Taper tie holes shall have the plug, specified in Section 03100 - Concrete Formwork, driven into the hole to the center of the wall before grouting. Completely fill taper tie holes with patching mortar except that non-shrink grout shall be used for all walls in contact with soil or liquid. On wall faces exposed to view, fill the outer 2 inches of the taper tie hole with patching mortar blended to match adjacent concrete.

C. Cracks: Repair cracks in excess of 0.01 inch by pressure injection of moisture-insensitive epoxy-resin system. Submit proposed material and method of repair for approval prior to making repairs.

D. Structural Repair: When required, make structural repairs after prior approval of City Engineer as to method and procedure, using specified epoxy adhesive or approved epoxy mortar.

3.03 FINISHING OF FORMED SURFACES

A. Unfinished Surfaces: Finish is not required on surfaces concealed from view in completed structure by earth, ceilings or similar cover, unless indicated otherwise on Drawings.

B. Rough Form Finish:

1. No form facing material is required on rough form finish surfaces.
2. Patch tie holes and defects. Chip off fins exceeding 1/4 inch in height.
3. Rough form finish may be used on concrete surfaces which will be concealed from view by earth in completed structure, except concealed surfaces required to have smooth form finish, as shown on Drawings.

C. Smooth Form Finish:

1. Form facing shall produce smooth, hard, uniform texture on concrete. Use plywood or fiberboard linings or forms in as large sheets as practicable, and with smooth, even edges and close joints.
2. Patch tie holes and defects. Rub fins and joint marks with wooden blocks to leave smooth, unmarred finished surface.
3. Provide smooth form finish on the wet face of formed surfaces of water-holding structures, and of other formed surfaces not concealed from view by earth in completed structure, except where otherwise indicated on Drawings. Walls that will be exposed after future construction, at locations indicated on Drawings, shall have smooth form finish. Smooth form finish on exterior face of exterior walls shall extend 2 feet below final top of ground elevation. Exterior face of all perimeter grade beams shall have smooth form finish for full depth of grade beam.

D. Related Unformed Surfaces: Tops of piers, walls, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed. Float unformed surfaces to texture reasonably consistent with that of formed surfaces. Continue final treatment on formed surfaces uniformly across unformed surfaces.

3.04 HOT WEATHER FINISHING

A. When hot weather conditions exist, as defined by Section 03310 - Structural Concrete and as judged by the City Engineer, apply evaporation retardant to the surfaces of slabs, topping and concrete fill placements immediately after each step in the finishing process has been completed.

3.05 FINISHING SLABS AND SIMILAR FLAT SURFACES TO CLASS A, B, AND C TOLERANCES

A. Apply Class A finish unless otherwise indicated on Drawings.

B. Shaping to Contour: Use strike-off templates or approved compacting-type screeds riding on screed strips or edge forms to bring concrete surface to proper contour. See Section 03100, Concrete Formwork for edge forms and screeds.

C. Consolidation and Leveling: Concrete to be consolidated shall be as stiff as practicable thoroughly consolidate concrete in slabs and use internal vibration in beams and girders of framed slabs and along bulkheads of slabs on grade. Consolidate and level slabs and floors with vibrating bridge screeds, roller pipe screeds or other approved means. After consolidation and leveling, do not permit manipulation of surfaces prior to finishing operations.

D. Tolerances for Finished Surfaces: Check tolerances by placing straightedge of specified length anywhere on slab. Gap between slab and straightedge shall not exceed tolerance listed for specified class.

Class	Straightedge Length in Feet	Tolerance in Inches
A	10	1/8
B	10	1/4

E. Float Finish:

1. After concrete has been placed, struck off, consolidated and leveled, do not work further until ready for floating. Begin floating when water sheen has disappeared, or when mix has stiffened sufficiently to permit proper operation of power-driven float. Consolidate surface with power-driven floats. Use hand floating with wood or cork-faced floats in locations inaccessible to power-driven machine and on small, isolated slabs.
2. After initial floating, re-check tolerance of surface with 10-foot straightedge applied at not less than two different angles. Cut down high spots and fill low spots to Class B tolerance. Immediately re-float slab to a uniform, smooth, granular texture.

3. Provide float finish at locations not otherwise specified and not otherwise indicated on Drawings.

F. Trowel Finish:

1. Apply float finish as previously specified. After power floating, use power trowel to produce smooth surface which is relatively free of defects but which may still contain some trowel marks. Do additional troweling by hand after surface has hardened sufficiently. Do final troweling when ringing sound is produced as trowel is moved over surface. Thoroughly consolidate surface by hand troweling operations.
2. Produce finished surface free of trowel marks, uniform in texture and appearance and conforming to Class A tolerance.

G. Broom or Belt Finish:

1. Apply float finish as previously specified. Immediately after completing floated finish, draw broom or burlap belt across surface to give coarse transverse scored texture.
2. Provide broom or belt finish at locations indicated on Drawings.

3.06 SEALER/DUSTPROOFER

A. Where sealer or sealer/dustproofer is indicated on Drawings, just prior to completion of construction, apply coat of specified clear sealer/dustproofing compound to exposed interior concrete floors in accordance with manufacturer's instructions.

3.07 CURING

A. Conform to requirements of Section 03390, Concrete Curing.

END OF SECTION

SECTION 03390
CONCRETE CURING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Curing of structural concrete.

1.02 UNIT PRICES

A. No separate payment will be made for concrete curing under this Section. Include payment in unit price for structural concrete.

1.03 REFERENCES

A. ACI 308 - Standard Practice for Curing Concrete.

B. ASTM C171 - Standard Specifications for Sheet Materials for Curing Concrete.

C. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

D. ASTM D44587 - Conducting Tests on Paint and Related Coatings and Materials Using a Fluorescent UV-Condensation Light-and Water-Exposure Apparatus.

1.04 SUBMITTALS

A. Conform to Section 01330, Submittal Procedures.

B. Product Data: Submit description of proposed curing method for concrete. When use of membrane-forming compound is proposed, submit manufacturer's technical information including material specifications, installation instructions and recommendations, and evidence that compound is satisfactory for intended application. State locations where curing compound will be used.

C. When membrane-forming compounds are to be used, submit certification by the manufacturer of compliance with specified requirements and compatibility with toppings, coatings, finishes, and adhesives to be applied.

PART 2 PRODUCTS

2.01 MATERIALS

A. Membrane-forming Curing Compound: Conform to ASTM C 309, Type 1D, and following requirements.

1. Minimum solids content: 30 percent.
2. Compound shall not permanently discolor concrete. When used for liquid- containing structures, curing compound shall be white-pigmented.
3. When used in areas that are to be coated, or that will receive topping or floor covering, material shall not reduce bond of coating, topping, or floor covering to concrete. Curing compound manufacturer's technical information shall state conditions under which compound will not prevent bond.
4. Conform to local, state and federal solvent emission requirements.

B. Clear Curing and Sealing Compound (VOC Compliant): Conform to ASTM C 309, Type 1, Class B, and the following requirements: 30 percent solids content minimum; non-yellowing under ultraviolet light after 500-hour test in accordance with ASTM D 4587. Sodium silicate compounds are not permitted. Conform to local, state and federal solvent emission requirements.

C. Sheet Material for Curing Concrete: ASTM C 171; waterproof paper, polyethylene film or white burlap-polyethylene sheeting.

D. Curing Mats (for use in Curing Method 2): Heavy shag rugs or carpets, or cotton mats quilted at 4 inches on center; 12 ounce per square yard minimum weight when dry.

E. Water for curing: Clean and potable.

PART 3 EXECUTION

3.01 CURING PROCEDURES

A. Comply with ACI 308 and the requirements specified herein. Protect freshly-deposited concrete from premature drying and excessively hot or cold temperatures. Maintain minimal moisture loss and relatively constant temperature during time necessary for hydration of cement and proper hardening of concrete.

B. Unformed Surfaces: For concrete surfaces not in contact with forms, use one of following procedures immediately after completion of placement and finishing.

1. Ponding or continuous sprinkling.
2. Absorptive mat or fabric kept continuously wet.
3. Sand or other covering kept continuously wet.
4. Continuous steam bath (not exceeding 150 degrees F at surface of concrete).
5. Vapor mist bath.
6. Membrane-forming curing compound applied according to manufacturer's recommendations. After the curing compound has dried, wet slab surfaces and cover with waterproof paper, polyethylene film, or white burlap-polyethylene sheeting after the application of the curing compound. Tape sheet seams together and provide sufficient weights to keep the sheeting in place. Wet the slab surface again if the sheeting becomes dislodged, and replace the sheeting.
7. Other moisture-retaining coverings as approved by City Engineer.

C. Restrictions on Use of Curing Compounds: Unless curing compound manufacturer certifies that curing compound will not prevent bond to cured surface, do not use curing compound on surfaces that will receive additional concrete, mortar or other cementitious finishing materials, or on surfaces to be waterproofed, sealed or painted.

D. Curing and Sealing Compounds: At locations indicated, cure exposed interior slabs and troweled slabs receiving mastic-applied adhesives with specified clear curing and sealing compound in accordance with manufacturer's recommendations. Do not store materials directly on curing membranes. Use plywood to protect curing membrane from damage. Immediately repair membranes damaged by foot traffic or other operations.

E. Duration of Curing: Continue curing until cumulative number of days or fractions of days during which ambient temperature is above 50 degrees F has totaled 7. Continue curing of water-retaining structures for a total of 14 days. When high-early-strength concrete has been used, continue curing for total of 3 days. Prevent rapid drying at end of curing period.

F. Formed Surfaces: During the curing period keep wet steel forms heated by sun and wood forms in contact with concrete. When forms are to be removed during curing period, employ curing materials or methods immediately. Continue such curing for remainder of curing period.

G. Temperature:

1. Cold Weather: When mean daily temperature of atmosphere is less than 40 degrees F, maintain temperature of concrete between 50 and 70 degrees F for required curing period. When necessary, make arrangements for heating, covering, insulating or housing concrete work in advance of placement to maintain required temperature and moisture conditions. Prevent damage or injury due to concentration of heat. When combustion heaters are necessary in enclosed or protected area where concrete slabs are being placed, vent heaters.
2. Hot Weather: In advance of placement make arrangements for shading, fog spraying, sprinkling, ponding or installation of windbreaks or wet covering of light color. Take such protective measures as quickly as concrete hardening and finishing operations will allow.
3. Temperature Changes: Control so rate of change in temperature of concrete is as uniform as possible. Do not permit temperature change to exceed 5 degrees F in any one hour or 50 degrees F in any 24-hour period.

H. Protection from Mechanical Injury: During curing period, protect concrete from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration. Protect finished concrete surfaces from damage caused by construction equipment, materials or methods, and by rain or running water. Do not load self-supporting structures in a way that over stresses concrete.

END OF SECTION

SECTION 03600
STRUCTURAL GROUT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Non-shrink grout used wherever grout is shown in the Documents, unless another type is specifically referenced. Two classes of non-shrink grout (Class I and II) and areas of application are specified.

1.02 UNIT PRICES

A. Include the cost for grout in the lump sum for each structure in which it will be used. No separate payment will be made for grout.

B. Measurement for extra grout (Class I and II) is on cubic foot basis. Payment includes associated work performed in accordance with related sections included in the Contract Documents.

C. Refer to Section 01270, Measurement and Payment for unit price procedures.

1.03 REFERENCES

A. CRD C621 - Corps of Engineers Specification for Non-shrink Grout.

B. ASTM C109 - Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or 50-mm Cube Specimens).

C. ASTM C230 - Specifications for Flow Table for use in Tests of Hydraulic Cement.

D. ASTM C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).

1.04 SUBMITTALS

A. Conform to Section 01330, Submittal Procedures.

B. Quality Control:

1. The Contractor shall submit manufacturer's literature certifying compliance with the specified properties for Class I and II grouts.

2. The Contractor shall submit manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of grout used in the work.

C. The Contractor shall submit manufacturer's written warranty as specified.

1.05 QUALITY ASSURANCE

A. Field Tests:

1. Compression test specimens will be taken during construction from the first placement of each type of grout, and at intervals thereafter as selected by the Project Manager to ensure continued compliance with these Specifications. The specimens will be made by the Project Manager or its representative.
2. Compression tests and fabrication of specimens for non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the Project Manager. A set of three specimens will be made for testing at 7 days, 28 days, and each additional time period as appropriate.
3. Grout already placed which fails to meet the requirements of these Specifications is subject to removal and replacement no additional cost to the City.
4. The cost of laboratory tests on grout will be borne by the City, but the Contractor shall assist the Project Manager in obtaining specimens for testing. However, the Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications. The Contractor shall supply materials necessary for fabricating the test specimens.

B. Warranty:

1. Provide one-year warranty for work provided under this Section.
2. Manufacturer's warranty shall not contain a disclaimer limiting responsibility to only the purchase price of products or materials furnished.
3. Manufacturer shall warrant participation with Contractor in replacing or repairing grout found to be defective due to faulty materials, as determined by industry standard test methods.

PART 2 PRODUCTS

2.01 APPLICATION

A. The following is a listing of typical applications and the corresponding type of grout which is to be used. Unless indicated otherwise, grouts shall be provided as listed below whether or not called for on the Drawings.

Application:	**Type of Grout**
Structural member base plates	Non-shrink Class II
Filling blockout spaces for embedded items such as railing posts, gate guide frames, etc	Non-shrink Class II (Class I where placement time exceeds 15 minutes
Toppings and concrete fill greater than 3 inches thick	Concrete Fill per Section 03310
Any application not listed above, where grout is called for on the Drawings	Non-shrink Class I, unless noted otherwise

2.02 PREPACKAGED GROUTS

A. Basic Requirements for Cementitious Non-Shrink Grout:

1. Provide prepackaged non-shrink grout that is inorganic, flowable, non-gas-liberating, non-metallic, and cement-based, requiring only the addition of water.
2. Deliver grout in original packaging with manufacturer's instructions printed on each container.
3. Select the specific formulation for each class of non-shrink grout specified to conform to that recommended by the manufacturer for the particular application.

4. Compressive strength at 28 days: 7000 psi minimum.
5. Do not use a grout for which the non-shrink property is based on a chemically generated gas or gypsum expansion.

B. Class I Non-Shrink Grout:

1. Supply Class I Grout conforming to these specifications and to CRD C621 and ASTM C1107 Grade C and B (as modified below) when tested using the amount of water needed to achieve the following properties:
   a. Fluid consistency (20 to 30 seconds) per CRD C611 at initial testing.
   b. Fluid consistency (45 seconds) per CRD C611 at 30 minutes after mixing.
   c. At temperatures of 45, 73.4, and 95 degrees F.
2. To satisfy non-shrink requirements, the length change from placement to time of final set shall not have a shrinkage greater than the amount of expansion measured after final set at 3 and 14 days. The expansion at 3 and 14 days shall not exceed the 28-day expansion.
3. Fluid grout shall pass through the flow cone, with a continuous flow, 1 hour after mixing.
4. Demonstrate in tests that grout maintains contact with the baseplate to provide an minimum effective bearing area of 95 percent of the gross contact area after final set.
5. The grout packaging shall list weight, maximum amount of mixing water to be used, maximum usable working time (pot life) at flowable consistency, and temperature restrictions for preparation and placement within which grout will meet specified requirements.

C. Class II Non-Shrink Grout:

1. Supply Class II Grout confirming to ASTM C1107 and the following requirements when tested using the amount of water needed to achieve the following properties:
   a. Flowable consistency: 140 percent flow on ASTM C230, five drops in 30 seconds.
   b. Fluid working time: 15 minutes, minimum.
   c. Flowable duration: 30 minutes, minimum.
2. When tested, the grout shall not bleed at maximum allowed water.

2.03 CURING MATERIALS

A. Curing materials: As specified in Section 03390, Concrete Curing and as recommended by the manufacturer of prepackaged grouts.

2.04 CONSISTENCY

A. Mix grouts to the consistency necessary to completely fill the space to be grouted. Dry pack consistency is such that the grout is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a grout of that consistency; the type of grout to be used shall be as specified herein for the particular application.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that base concrete has attained design strength before grout is placed.

B. When cementitious grouts are used on concrete surfaces, saturate the concrete surface with water for 24 hours prior to placement of cement-based grout. Upon completion of saturation period remove excess water prior to grouting.

3.02 GROUTING PROCEDURES

A. Prepackaged Grouts: Perform mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts according to the written instructions of the manufacturer. Use prepackaged materials in the quantities and proportions as directed by the manufacturer unless there is certified test data verifying that the specified properties are attained by modified mix.

3.03 CONSOLIDATION

A. Place grout in such a manner, for the consistency necessary for each application, so as to assure that the space to be grouted is completely filled.

END OF SECTION

SECTION 03720
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 301, Specifications for Structural Concrete.
   b. 506.2, Specification for Shotcrete.
2. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   j. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   k. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   l. C596, Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
   m. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.

o. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
p. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
q. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
r. D4259, Standard Practice for Abrading Concrete.
s. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

3. NSF International (NSF): 61, Standard for Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and reinforcing steel. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: Surface defect such as honeycomb, rock pockets, indentations and surface voids greater than 3/16-inch deep, surface voids greater than 3/4-inch diameter, cracks in liquid containment structures 0.005-inch wide and wider, cracks in other structures 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances which include but are not limited to fins, form pop-outs, and other projections, and at exposed concrete which includes texture irregularities, stains, and other color variations that cannot be removed by cleaning.

C. High-Pressure Water Blasting: Sometimes referred to as hydro-demolition. Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. Low-Pressure Spray Mortar: Mortar suitable to be applied by low-pressure spraying, and in small areas may be applied by hand troweling.

E. New Concrete: Concrete less than 60 days old forming structures constructed as part of the Work.

F. Rebound: Shotcrete material, mostly aggregates, that bounce off a surface against which shotcrete was projected.

G. Shotcrete: Mortar pumped through hose and projected at high velocity.

1.03 GENERAL

A. This section is to be used for repair of new concrete provided by the contractor in the event of damage or deficiencies resulting from construction activities.

1.04 SUBMITTALS

A. Action Submittals:

1. Product data sheets for each material supplied.
2. Drawings indicating results of sounding for hollow areas including location, size, and estimated quantity of hollow-sounding areas for each repair location.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Mesh manufacturer's installation instructions and allowable load criteria.
3. Written description of equipment proposed for concrete removal and surface preparation.
4. Certificates:
   a. Shotcrete Nozzleman: Current ACI Certification for each proposed nozzleman.
   b. Manufacturer's Certificate of Compliance that proposed repair mortar systems:
      1) Meet or exceed specified performance criteria when tested in accordance with Article Field Quality Control.
      2) Are prepackaged, shrinkage compensated, specially designed for use on vertical and overhead surfaces that are exposed to potable water.
   c. Mortar Manufacturer's Certificate of Proper Installation.
   d. Confirmation material is certified to meet requirements of NSF 61.

5. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Repair mortar system manufacturer's representative.
   c. Independent Testing Laboratory.
6. Repair mortar system manufacturer's proposed modified test procedures for ASTM C109/C109M and ASTM C882/C882M test methods.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator:
   a. Trained and experienced applicator recognized or certified by repair mortar system manufacturer.
   b. For Repair System B, in lieu of recognition or certification, demonstrate application of repair mortar manufacturer's system and obtain Certification of Proper Installation, in accordance with Article Manufacturer's Services.

B. Independent Testing Laboratory: Meet criteria stated in ASTM E699.

C. Demonstration Mockup for Shotcrete Mortar and/or Low-Pressure Spray Mortar Repair System:

1. For each type of repair mortar system to be used, prepare one demonstration mockup in each vertical and overhead orientation of at least 5 feet by 5 feet with average thickness, and containing reinforcement, representative of area being repaired on Project. Alternatively, a repair area in each vertical and overhead orientation that is representative of area to be repaired in terms of size, thickness, and reinforcement, may be used for demonstration in lieu of mockups; subject to acceptance by Engineer.
2. Repair Mortar System Manufacturer's Demonstration:
   a. Schedule time for manufacturer's demonstration of repair system proposed for Project.
   b. Prepare mortar to specified consistency for testing and placement.
   c. Cure portions of each type of surface to be repaired using proposed curing procedure and materials, including overhead and vertical applications.
   d. Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.

e. Demonstrate the following:
   1) Mixing and application equipment capabilities and procedures, including flow of material from nozzle or sprayer.
   2) Nozzle operator and person in charge of low-pressure sprayer, capabilities and ability to follow prescribed application procedures and properly operate equipment and apply surface repair materials.
f. Compression Strength Test: Take core samples from demonstration placement and deliver to independent testing laboratory for testing at 7 days and 28 days.

D. Demonstration Mockup for Hand-Applied Repair Mortar:

1. For each type of repair mortar system to be used, prepare one demonstration mockup in each vertical and overhead orientation of average size and thickness, and containing reinforcement, representative of area being repaired on Project. Alternatively, a repair area in each vertical and overhead orientation that is representative of area to be repaired in terms of size, thickness, and reinforcement, may be used for demonstration in lieu of mockups; subject to acceptance by Engineer.
2. Repair Mortar System Manufacturer's Demonstration:
   a. Schedule time for manufacturer's demonstration of repair system proposed for Project.
   b. Prepare mortar to specified consistency, for testing and placement.
   c. Cure portions of each type of surface to be repaired using proposed curing procedure and materials, including overhead and vertical applications.
   d. Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.
   e. Demonstrate mixing and application procedures.
   f. Compression Strength Test: Take core samples from demonstration placement and deliver to independent testing laboratory for testing at 7 days and 28 days.

E. Pre-repair Conference:

1. Required Meeting Attendees:
   a. Contractor.
   b. Repair Subcontractor.
   c. Technical representative for repair material manufacturer.
   d. Engineer.

2. Schedule and conduct prior to conducting mockups and incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include, but not limited to:
   a. Review of field conditions. Conduct field observations of Work to be performed.
   b. Based on above observations, repair material manufacturer's technical representative shall confirm material selection and make Project-specific repair method recommendations.
   c. Technical representative for repair material manufacturer shall review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
   d. Other specified requirements requiring coordination.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 SYSTEM A—SHOTCRETE MORTAR

A. Mortar Materials:

1. Blend of selected portland cements, microsilica, and specially graded aggregates and fibers applicable for vertical and overhead surfaces.
2. Materials shall not contain asbestos, chlorides, nitrates, added gypsum, added lime, or high aluminum cements.
3. Noncombustible before and after cure.
4. Furnish in factory proportioned unit.
5. Workability from 1/4 inch in depth and greater.

B. Mixed Mortar Properties:

1. Working Time: 5 minutes to 10 minutes.
2. Finishing Time: 10 minutes to 20 minutes.
3. Color: Dark gray.

C. Cured Mortar Properties:

1. Compressive strength for 2-inch cubes in accordance with ASTM C109/C109M, or 3-inch cubes in accordance with manufacturer's modification to ASTM C109/C109M:
   a. 7 Days: 6,000 psi minimum.
   b. 28 Days: 7,000 psi minimum.
2. Flexural Strength (Modulus of Rupture), ASTM C78/C78M or ASTM C348 (Modified) at 28 Days: 1,100 psi minimum.
3. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 400 psi minimum.
4. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum.
5. Mortar shall not produce a vapor barrier.
6. Certified to meet requirements of NSF 61 for contact with potable water.

D. Manufacturers and Products: BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; Shotpatch 21F.

2.02 SYSTEM B—LOW-PRESSURE SPRAY MORTAR

A. One-component, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.

B. Cured materials mixed in accordance with manufacturer's instructions shall conform to the following criteria:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 6,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,100 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent, at 28 Days: 3,000 psi minimum.
4. Direct Tensile Bond Strength, ASTM C496/C496M at 28 Days: 300 psi minimum.
5. Drying Shrinkage, ASTM C157/C157M Modified at 28 Days or ASTM C531: 0.1 percent maximum.
6. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum.
7. System shall not produce a vapor barrier.
8. Certified to meet requirements of NSF 61 for contact with potable water.

9. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only addition of water.
10. Free of chlorides and other chemicals causing corrosion.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; Emaco S88 CI.
2. Sika Corp., Lyndhurst, NJ; SikaRepair 224.

2.03 SYSTEM C—POLYMER-MODIFIED REPAIR MORTAR

A. Polymer-modified, one- or two-component, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

B. Cured Mortar Properties:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 7,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,200 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent at 28 Days: 2,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
5. Drying Shrinkage, ASTM C596 at 28 Days: 0.12 percent maximum.
6. Freeze Thaw Resistance, ASTM C666/C666M, at 300 Cycles: 90 percent RDM.
7. Certified to meet requirements of NSF 61 for contact with potable water.

C. Manufacturers and Products: Sika Corp., Lyndhurst, NJ; SikaTop 123 PLUS.

2.04 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03310, Structural Concrete.

2.05 REINFORCEMENT

A. Deformed Reinforcing Bars: As specified in Section 03211 Reinforcing Steel.

B. Mesh Reinforcement: As specified in Section 03211 Reinforcing Steel.

C. Tie Wire: 16-gauge, galvanized.

D. Mesh Anchors:

1. Manufacturers and Products:
   a. Powers Fastening, Inc., Brewster, NY; Tie Wire Version of Power-Stud.
   b. Hilti Fastener Systems, Tulsa, OK; Kwik Bolt II HHDCA, 1/4-inch ceiling hanger.

2.06 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic portland cement concrete or mortar to hardened portland cement concrete.

1. Mixed Bonding Agent Properties:
   a. Pot Life: 75 minutes to 105 minutes.
   b. Contact Time: 24 hours.
   c. Color: Concrete Gray.
2. Cured Cementitious Adhesive Properties:
   a. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
   b. Flexural Strength, ASTM C348: 1,000 psi minimum.
   c. Slant Shear Bond Strength, ASTM C882/C882M at 14 Days:
      1) 2-Hour Open Time: 2,500 psi minimum.
      2) 24-Hour Open Time: 2,000 psi minimum.
3. Bonding agent shall not produce a vapor barrier.
4. Compatible with repair system.

B. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; Emaco P24.
2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
3. Euclid Chemical Co., Cleveland, OH: Dural Prep AC.

2.07 EVAPORATION RETARDANT

A. As specified in Section 03390, Concrete Curing.

2.08 CURING COMPOUND

A. As specified in Section 03390, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system.

3.02 PREPARATION

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer, and review proposed extent of repair with Engineer.

B. Remove unsound, honeycombed, deteriorated, or otherwise defective areas of concrete from work areas.

1. Use 8,000 psi minimum high-pressure water blasting machine as required for Site conditions.
2. Remove concrete to abrade substrate concrete surfaces to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
3. Where final surface is required to be flush with existing adjacent surface remove existing concrete depth as required for application of minimum thickness of repair mortar.

C. Do not use power-driven jackhammers, chipping hammers, or scabblers unless water blasting is not permitted or practical due to Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded reinforcing steel. Roughen polished saw-cut edge by high-pressure water blasting or abrasive blasting.

G. Remove concrete adjacent to reinforcing bar to a minimum of 1-inch clearance around reinforcing bar for application and bonding of new repair mortar to circumference of exposed reinforcing bar if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around reinforcing bar is exposed during concrete removal.
2. 25 percent or more of circumference around reinforcing bar is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and reinforcing bar has been destroyed or has deteriorated as determined by Engineer.

H. Clean exposed reinforcing steel bars of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar as required by and in accordance with repair mortar manufacturer’s printed instructions.

K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.03 REINFORCEMENT INSTALLATION

A. Provide reinforcement when existing reinforcement is not exposed, and when mortar application is more than 3 inches deep, unless otherwise shown on Drawings.

B. Install mesh anchors in accordance with mesh manufacturer’s instructions.

C. Fasten reinforcing bars to mesh anchors with tie wire to prevent from moving during placement of repair mortar.

D. Lap reinforcement mesh a minimum of one mesh spacing and securely fasten mesh to mesh anchors, or to reinforcement fastened to mesh anchors, with tie wire at intervals no more than 12 inches to prevent movement during application of repair mortar.

3.04 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment, from being damaged by overshooting, rebound, and dust, as applicable for repair mortar system used, from shotcrete mortar or low-pressure spray mortar.

3.05 SYSTEM A—SHOTCRETE MORTAR APPLICATION

A. Apply shotcrete mortar in accordance with manufacturer's instructions.

B. Do not reuse rebound materials.

C. Apply mortar utilizing dry mix process, in accordance with ACI 506.2.

D. Shotcrete mortar shall emerge from nozzle in a steady, uninterrupted flow. If flow becomes intermittent, direct flow away from the Work until flow of mortar becomes constant.

E. Applied Shotcrete Mortar: Minimum thickness of 1-1/2 inches to 2 inches of cover over existing reinforcement, or to level of surrounding concrete surface, whichever results in thicker coat.

F. Nozzle Position: Hold nozzle approximately at right angles to and at a distance from surface in accordance with shotcrete repair mortar system manufacturer's instructions for type of application, nozzle, and air pressure used.

G. Reinforcing Steel Encasement:

1. Modify procedure of shooting shotcrete mortar to better direct material around reinforcement bars.
2. Prevent shotcrete mortar from building up on reinforcement steel when shooting on, around, through, and behind steel to eliminate voids.
3. Provide dense void-free encasement of reinforcement steel.

H. Shotcreting More than One Layer: In accordance with shotcrete repair mortar system manufacturer's printed instructions.

I. Apply finish to exposed shotcrete mortar surface to match existing surface and in accordance with manufacturer's instructions.

J. Rebound Removal: Continuously throughout shotcrete mortar application, remove rebound, sand, and miscellaneous debris, and dispose off Site at an approved disposal facility.

K. Cure as specified in Article Curing.

3.06 SYSTEM B—LOW-PRESSURE SPRAY MORTAR APPLICATION

A. Mix mortar in accordance with manufacturer's printed instructions.

B. After priming prepared substrate concrete surface per manufacturer's recommendations, apply mortar by low-pressure spraying equipment, unless noted otherwise.

C. Bonding Agent:

1. Use bonding agent for hand applied areas, in accordance with repair mortar manufacturer's instructions.
2. Application of repair mortar over bonding agent shall be completed within time frame recommended by bonding agent manufacturer.
3. Consult with manufacturer for optimum and minimum acceptable degrees of surface tackiness of coat.

D. Work mortar firmly and quickly into repair area.

E. Finish repair mortar to smooth even surface matching adjacent concrete surface with steel trowel finish.

F. Cure as specified in Article Curing.

3.07 SYSTEM C—POLYMER-MODIFIED REPAIR MORTAR APPLICATION

A. Mix mortar in accordance with manufacturer's printed instructions.

B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions. Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.

C. Place mortar by hand or low-pressure spray and trowel to specified surface finish, in accordance with requirements of repair material's printed instructions.

D. Finish repair mortar to smooth even surface matching adjacent concrete surface with steel trowel finish.

E. Cure as specified in Article Curing, and in accordance with manufacturer's printed instructions.

3.08 CURING

A. Prior to curing, apply water fog to repair mortar system in accordance with repair mortar system manufacturer's printed instructions.

B. Cure in accordance with repair mortar manufacturer's printed instructions.

C. Where permitted by repair mortar manufacturer's printed instructions, commence water curing after repair mortar system application and when curing will not cause erosion of mortar.

D. Continuously water cure repair mortar system for a period of 7 days.

E. Do not cure using curing compound or membrane, unless method is part of repair mortar system manufacturer's printed instructions and approval is obtained from Engineer.

F. Cure intermediate layers of repair mortar in accordance with repair mortar manufacturer's printed instructions.

G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03390, Concrete Curing.

3.09 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.

2. Obtain production samples of mixed wet mortar materials from nozzle, or mixer, during construction for compliance with Specifications for testing at 7 days, and 28 days. Alternatively, take core samples in accordance with ASTM C42/C42M from applied mortar material for testing at 7 days and 28 days.
3. Provide a minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Direct Tension Bond Test:

1. In Situ Bond Testing: Perform tension bond test in accordance with ASTM C1583/C1583M.
2. Record locations on in situ bond tests on each type of applied repair mortar.

D. Testing laboratory retained by Owner will test the following:

1. Compression Strength Test:
   a. Testing will follow a “modified” ASTM C109/C109M.
   b. A minimum of three production samples of mixed material will be obtained from each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days. Alternatively, take core samples in accordance with ASTM C42/C42M from applied mortar material for testing at 7 days and 28 days.
   c. Record location where repair mortar is being applied at time production samples are obtained.
2. Direct Tension Bond Test:
   a. Two core samples will be obtained and tested for each 2,000 square feet of repair work.
   b. Cores will be 2-1/2-inch or 3-inch diameter to a total depth equal to at least 2.5 times repair mortar thickness.
   c. Bond Strength of Repair Mortar to Substrate Concrete: 300 psi minimum in direct tension without failure or movement.
   d. Record locations of Bond Tests on each type of applied repair mortar tested.

E. Retest mortar repairs that do not meet test requirements.

F. Repair and fill holes using same repair mortar where core samples have been removed.

3.10 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge. Remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.

D. Failed Bond Tests: Remove affected areas of repair mortar represented by failed bond test results. Prepare substrate surface and reapply repair mortar as specified herein above.

E. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.11 MANUFACTURER’S SERVICES

A. Provide repair mortar system manufacturer’s representative at Site for review acceptability of surface preparation, mixing and installation assistance, inspection, and Certification of Proper Installation.

3.12 CLEANING

A. Remove overshot shotcrete low-pressure spray repair mortar and rebound materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of or repair areas, finishing, and curing, and dispose offsite at an approved disposal site.

END OF SECTION

SECTION 05520
METAL RAILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Aluminum Association, Incorporated (AA): DAF45, Designation System for Aluminum Finishes.
2. American Iron and Steel Institute (AISI).
3. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   e. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   f. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   g. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   h. A554, Standard Specification for Welded Stainless Steel Mechanical Tubing.
   i. E985, Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.
4. International Code Council (ICC): International Building Code (IBC).
5. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 DEFINITIONS

A. Handrails: Synonymous with terms; i.e., guardrail system, railing system, ramp-rail system, and stair-rail system. Handrails are comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.

B. ICC Evaluation Services Report for concrete anchor manufacturers.

C. Special Inspection: As governed by the ICC IBC.

D. Toeboards: Vertical barrier at floor level usually erected on handrails along exposed edges of floor or wall openings, platforms, ramps, or stairs to prevent miscellaneous items from falling through.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Indicate handrail profiles, sizes, connections, anchorage, size and type of fasteners, and accessories. Project-specific scale plans and elevations of handrails.
   b. Manufacturer's literature and catalog data of handrail and components.
   c. Design Data: Calculations or test data using design performance loads and include the following:
      1) Bending stress in, and deflection of, posts in accordance with ASTM E985.
      2) Stress in post base connection.
      3) Calculation of anchorage forces and comparison of these forces to ICC IBC recommendations regarding safe allowable design loads of anchorages.
      4) For concrete anchor spacings less than 12 anchor diameters and edge distances less than six anchor diameters, make reduction in allowable pullout and shear values. Provide independent laboratory inspection service for ICC Evaluation Services Report values with Special Inspection.

B. Informational Submittals:

1. Manufacturer's assembly and installation instructions.
2. Special Inspection:
   a. Manufacturer's instructions for Special Inspection of concrete anchors.
   b. Special Inspection report in accordance with Article Tests and Inspections.

3. Test Reports: Test data may supplement load calculations providing data covers the complete handrail system, including anchorage:
   a. Test data for handrail and components showing load and deflection due to load, in enough detail to prove handrail is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
      1) Railing and post connections.
      2) Railing wall connections.
      3) Post and base connections.
      4) Railing expansion joint connections.
   b. Deflection Criteria: In accordance with ASTM E985 and design loads specified.
   c. Aluminum Rail Piping: Test data showing yield strength of pipe as-delivered equals or exceeds values specified in this section.
   d. Concrete Anchors: Calculations and test data for review prior to use, on anchors other than those specified.
4. Manufacturer's written recommendations describing procedures for maintaining handrails including cleaning materials, application methods, and precautions to be taken in the use of cleaning materials.
5. Manufacturer's Certificate of Proper Installation.

1.04 QUALITY ASSURANCE

A. Qualifications: Calculations required for design data stamped by a registered civil or structural engineer licensed in the state of Texas.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Handrails adequately packaged and wrapped to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping until railing is completely installed.

B. Aluminum Handrails:

1. Shop assemble into practical modules of lengths not exceeding 24 feet for shipment.
2. Deliver toeboards loose for field assembly.
3. Deliver clear anodized handrail pipe and posts with protective plastic wrap.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Thermal Movements: Allow for thermal movement resulting from the following maximum range in ambient temperature in design, fabrication, and installation of handrails to prevent buckling, opening up of joints, over stressing of components, connections and other detrimental effects. Base design calculation on actual surface temperatures of materials due to both solar heat gain and night time sky heat loss. Temperature change is difference between high or low temperature and installation temperature.

1. Temperature Change Range: 70 degrees F, ambient; 100 degrees F, material surfaces.

PART 2 PRODUCTS

2.01 DESIGN PERFORMANCE

A. Structural Performance of Handrails: Design, test, fabricate, and install handrails to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in each of the respective components comprising handrails.

1. Top Rail of Handrails: Capable of withstanding the following load cases applied:
   a. Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC.
   b. Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
   c. Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
2. In-Fill Area of Railing Systems:
   a. Capable of withstanding a horizontally applied normal load of 50 pounds applied to 1 square foot at any point in the system including panels, intermediate rails, balusters, and openings and space between railings.
   b. Horizontal concentrated load need not be assumed to act concurrently with loads on top rails of handrails.
3. Mid-rails with corner returns to withstand a 300-pound concentrated vertical load applied at any point or direction without damage and loosening of pipe, fittings, or attachment hardware.

4. Concrete Anchors for Handrail Wall Brackets: Anchors with a strength required by calculations with concrete strength assumed at 4,000 psi and in conformance with ICC IBC.
5. Concrete Anchors: In accordance with ICC IBC for size, length, embedment, spacing, and edge distance to match required loads shown in calculations.

2.02 ALUMINUM HANDRAILS

A. General:

1. Furnish pre-engineered and prefabricated three rail handrails.
2. Pop rivets and glued railing construction not permitted.

B. Manufacturers:

1. Thompson Fabricating Co., Birmingham, AL.
2. Moultrie Manufacturing, Moultrie, GA; Wesrail II.
3. Or Equal.

C. Rails, Posts, and Formed Elbows: Extruded Alloy 6105-T5 or 6061-T6, minimum tensile strength of 38,000 psi and minimum yield strength of 35,000 psi.

1. Miscellaneous Aluminum Parts: 6063-T6 or 6061-T6 extruded aluminum of adequate strength for all loads.
2. Post and Railing: Nominal 1-1/2-inch diameter.
   a. Rails: 1.900-inch outside diameter by 0.145-inch wall thickness, Schedule 40.
   b. Posts: 1.900-inch outside diameter by 0.200-inch wall thickness, Schedule 80.
   c. Solid dowel interconnectors of 6105-T5 or 6061-T6 aluminum.

D. Fittings:

1. Handrail and Post Fittings: Extruded, machined bar stock, permanent mold castings, or die castings of sufficient strength to meet load requirements. Fittings shall match color of pipe in handrails. Sand cast parts not permitted.
2. Concrete Top Mount Post Base:
   a. Four holes in base for concrete anchors. For narrow walls or curbs, furnish two holes in base for concrete anchors with required edge distance.

b. Manufacturers and Products:
   1) Thompson Fabricating Co.; Part No. TBF-3.4 and Part No. TBF-3.2 for narrow walls and curbs.
   2) Moultrie Manufacturing Co.; Part No. WII4HB and WII2HB for narrow walls and curbs.

3. Concrete Side Mounted Handrail Bracket: Extruded aluminum, Alloy 6063-T6 with four holes for bolts or concrete anchors.
   a. Manufacturers and Products:
      1) Thompson Fabricating Co.; Part No. TSM-1.5.
      2) Moultrie Manufacturing Co.; Part No. WIISMB.
4. Concrete Anchors for Securing Bases and Brackets to Concrete: Type 304 or Type 316 stainless steel 1/2-inch concrete anchors.
5. Handrail Connections for Metal Stairway Stringers:
   a. Extruded aluminum bracket, Alloy 6063-T6.
   b. Brackets bolts 1/2-inch diameter Type 304 or Type 316 stainless steel bolts.
   c. Offset Adjustable Stair Fitting:
      1) Thompson Fabricating Co.; Part No. ASF of cast Al-mag.
      2) Moultrie Manufacturing Co.; Standard and custom elbow angles, Part No. W51XXX (numbers vary based on angle).
   d. Additional Offset Adjustable Fitting for Picket Railing System: Thompson Fabricating Co.; Part No. APF of cast Al-mag.
   e. Base Connection:
      1) Manufacturers and Products:
         a) Thompson Fabricating Co.; Part Nos. SMB-2 or SMB-3, ASF, APF.
         b) Moultrie Manufacturing Co.; Part No. WIISMBEXT.
6. Handrail Connections for Metal Beams:
   a. Extruded aluminum bracket, Alloy 6063-T6.
   b. Bracket bolts 1/2-inch diameter Type 304 stainless steel bolts.
   c. Manufacturers and Products:
      1) Thompson Fabricating Co.; Part Nos. SMB-2 or SMB-3. Use Part No. TSM-1.5 if bracket is attached to flat side of channel.
      2) Moultrie Manufacturing Co.; Part No. WIISMBEXT. Use Part No. WIISMB if bracket is attached to flat side of channel.
7. Handrail Wall Brackets: Adjustable wall fitting, with provision for three 3/8-inch Type 304 stainless steel bolts or concrete anchors.
   a. Manufacturers and Products:
      1) Thompson Fabricating Co.; Part No. AWF cast Al-mag aluminum bracket.
      2) Moultrie Manufacturing Co.; Part No. W41100.

8. Miscellaneous Rail to Post Fittings:
    a. Aluminum Tee Fittings:
        1) Manufacturers and Products:
            a) Thompson Fabricating Co.; Part Nos. TF-1 and TX-1.
            b) Moultrie Manufacturing Co.; Part Nos. WIIT40, WIIT40/05, WIIT80, and WIIT80/05.
    b. Aluminum Ell Fittings:
        1) Manufacturers and Products:
            a) Thompson Fabricating Co.; Part Nos. TE-1, TE-2, and TE-3.
            b) Moultrie Manufacturing Co.; Part No. 51900.
    c. Aluminum Splice Lock:
        1) Manufacturers and Products:
            a) Thompson Fabricating Co.; Part No. SL-1.
            b) Moultrie Manufacturing Co.; Part No. WIIS40.
    d. Aluminum Expansion Joint Splice:
        1) Manufacturers and Products:
            a) Thompson Fabricating Co.; Part No. ES-1.
            b) Moultrie Manufacturing Co.; Part No. WII40, omit set screws on one side.
    e. Formed Aluminum Wall Flange:
        1) Manufacturers and Products:
            a) Thompson Fabricating Co.; Part No. CF-2.
            b) Moultrie Manufacturing Co.; Part No. 41250.
9. Toeboards and Accessories:
    a. Material: Molded or extruded 6063 or 6061 aluminum.
    b. Manufacturers:
        1) Thompson Fabricating Co.
        2) Moultrie Manufacturing Co.; Part No. WIIKP20.
10. Castings for Handrails:
    a. Cast Al-mag with sufficient strength to meet load and test requirements.
    b. Anodizable grade finish with excellent resistance to corrosion when subject to exposure of sodium chloride solution intermittent spray and immersion.

E. Concrete Embedded Metal Anchorages: In accordance with Section 05501, Metal Fabrications.

F. Finishes:

1. Handrail Pipe and Post: In accordance with AA DAF45, designation AA-M32-C22-A41.
2. Cast Fittings and Toeboards: In accordance with AA DAF45, designation AA-M10-C22-A41.

2.03 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Bolts and Nuts for Bolting Handrail to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type A 316 stainless steel with minimum yield strength for bolts of 95,000 psi, unless otherwise shown.

B. Concrete Anchors:

1. Stainless steel Type 304 or Type 316.
2. Use ICC IBC approved values for size, length, embedment, spacing, and edge distance to match required loads shown in calculations.

C. Epoxy (Adhesive) Anchors:

1. Heavy-duty 1/2-inch minimum diameter, for exterior use only in accordance with Section 05501, Metal Fabrications, as an alternative to mechanical concrete anchors.
2. Design and provide number required.
3. Do not use where fire or elevated temperatures above 110 degrees F exist.

2.04 FABRICATION OF ALUMINUM HANDRAILS

A. Shop Assembly:

1. Post Spacing: Maximum 6-foot horizontal spacing.
2. Railing Posts Bolted to Metal or Concrete:
   a. In lieu of field cutting, provide approved fitting with sufficient post overlap, containing provisions for vertical adjustment.
   b. Field fit-up is required.
3. Free of burrs, nicks, and sharp edges when fabrication is complete.
4. Welding is not permitted.

B. Shop/Factory Finishing:

1. Use same alloy for uniform appearance throughout fabrication for railings.
2. Handrail and Post Fittings: Match fittings with color of pipe in handrail.
3. Sand cast parts not permitted.

C. Tolerances:

1. Shop assemble rails, posts, and formed elbows with a close tolerance for tight fit.
2. Fit dowels tightly inside posts.

PART 3 EXECUTION

3.01 GENERAL

A. Provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on the actual structure. Install railing with a base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in the field and exceeds plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest set-screw or bolt in base fitting.

B. Field fabrication of aluminum railing systems not permitted.

C. Modification to structure not permitted where handrail is attached.

D. Mount handrails only on completed walls. Do not support handrails temporarily by means not satisfying structural performance requirements.

3.02 HANDRAIL INSTALLATION

A. Assembly and Installation: Perform in accordance with manufacturer's written recommendations for installation.

B. Protection from Entrapped Water:

1. Make provisions in exterior and interior installations subject to high humidity to drain water from railing system.
2. Posts mounted in concrete, bends, and elbows occurring at low points drill weep holes of 1/4-inch diameter at lowest possible elevations, one hole per post or rail. Drill hole in the plane of the rail.

C. Expansion Joints:

1. Maximum intervals of 54 feet on center and at structural joints.
2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.
3. Fasten to one side using 3/8-inch diameter set-screw. Place set-screw at bottom of pipe.
4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span expansion joints in structural walls and floors supporting the posts.

D. Setting Posts:

1. Surface Mounted:
   a. Bolt post baseplate connectors firmly in place.
   b. Shims, wedges, grout, and similar devices for handrail post alignment not permitted.

E. Posts and Rails:

1. Set posts plumb and aligned to within 1/8 inch in 12 feet.
2. Set rails horizontal or parallel to slope of steps to within 1/8 inch in 12 feet.
3. Install posts and rails in same plane. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
4. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

F. Toeboard:

1. Provide at handrails, except where 4-inch or higher concrete curbs are installed or at gates.
2. Accurately measure in field for correct length; after handrail post installation cut and secure to posts.
3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
4. Aluminum Toeboards: Provide expansion and contraction connections between each post.

3.03 FIELD FINISHING

A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09901, Protective Coatings.

3.04 TESTS AND INSPECTIONS

A. Perform Special Inspection for anchors where ICC Evaluation Services Reports require them for anchor strength value used.

B. Provide an independent test laboratory to perform Special Inspection.

3.05 CLEANING

A. Wash railing system thoroughly using clean water and soap. Rinse with clean water.

B. Do not use acid solution, steel wool, or other harsh abrasive.

C. If stain remains after washing, restore in accordance with manufacturer's recommendations or replace stained handrails.

END OF SECTION

SECTION 05530
METAL GRATINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A510, Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
   c. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   d. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   e. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
3. National Association of Architectural Metal Manufacturers (NAAMM):
   a. MBG 531, Metal Bar Grating Manual.
   b. MBG 532, Heavy-Duty Metal Bar Grating Manual.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
   b. Grating Anchorage: Show details of anchorage to supports to prevent displacement from traffic impact.
   c. Product data for grating, grating clips, anchors, accessories, and other manufactured products specified herein.
   d. Manufacturer’s specifications, including coatings, surface treatment, and finishes.

B. Informational Submittals:

1. Special handling and storage requirements.
2. Installation instructions.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Insofar as is practical, factory assemble items.

B. Package and clearly tag parts and assemblies that are, due to necessity, shipped unassembled.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. IKG Industries, Houston, TX.
3. Ohio Gratings, Inc., Canton, OH.
4. Seidelhuber Metal Products, Inc., South San Francisco, CA.

2.02 GRATING MATERIALS

A. Aluminum: Provide alloy and temper as designated below.

1. Bearing Bars and Banding: ASTM B221 alloy 6061-T6 or 6063-T6.
2. Swaged Crossbar Rods: ASTM B221 alloy 6061 or 6063, or ASTM B210 alloy 3003.
3. Finish: Mill.

2.03 METAL BAR GRATING

A. General Requirements:

1. Maximum Service Load:
   a. Light Duty (Type A): 100 psf uniformly distributed load.
2. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
3. Bearing Bar Spacing:
   a. Light Duty: 1-3/16 inch maximum, center-to-center.

4. Cross Bar Spacing: 4 inches maximum, center-to-center. For aluminum I-bar grating with depths greater than 2 inches, provide cross bars at 2 inches maximum, center-to-center.
5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 531 or as shown on Drawings.

B. Grating Materials:

1. I-bar grating fabricated by swaging crossbars between extruded I-shaped bearing bars.

C. Surface: Striated.

D. Stair Treads:

1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
2. Nosings: Integral ribbing and serrated edge on one long axis of tread, or nonslip abrasive on each tread along one long edge.
3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

2.04 ACCESSORIES

A. Embedded Frames: As indicated on Drawings and as specified in Section 05501, Metal Fabrications.

B. Grating Clamps:

1. Use at flanged beam and bolted angle frame supports.
2. Removable from above grating walkway surface.
3. Provide hat bracket, recessed bolt, and bottom clamp of same material as grating.
4. Manufacturers and Products:
   a. Direct Metals Company, LLC, Kennesaw, GA; Grating Clamp.
   b. Grating Fasteners, Inc., Harvey, LA; G-Clip.

C. Anchor Stud and Saddle Clip:

1. Use at embedded angle frame supports with stud anchor and nut recessed below top of grating surface.
2. Removable from above grating walkway surface.
3. Provide Type 316 stainless steel welded threaded stud anchor, nut, washer, and saddle clip.

4. Manufacturers and Products:
   a. Welded Stud Anchor:
      1) Nelson Stud Welding, Inc., Elyria, OH.
      2) Stud Welding Associates, Inc. Elyria, OH.
   b. Saddle Clip:
      1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
      2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
      3) Struct-Fast, Inc., Baltimore, MD; Gratefast.

2.05 FABRICATION

A. General:

1. In accordance with NAAMM MBG 531 or NAAMM MBG 532.
2. Do not weld aluminum grating.
3. Conceal fastenings where practical.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Cutouts:
   a. Fabricate in grating sections for penetrations indicated.
   b. Arrange to permit grating removal without disturbing items penetrating grating.
   c. Edge band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.
6. Do not notch bearing bars at supports to maintain elevation.
7. Field measure areas to receive grating. Verify dimensions of new fabricated supports, and fabricate to dimension required for specified clearances.
8. Section Length: Sufficient to prevent section from falling through clear opening when oriented in the span direction and one end is touching either the concrete or the vertical leg of grating support.
9. Minimum Bearing: 1 inch for grating depth up to 2-1/4 inches and 2 inches for grating depth greater than 2-1/4 inches.
10. Banding and Toe Plates: Same material as grating and welded to bearing bars in accordance with requirements of NAAMM MBG 531 and NAAMM MBG 532.

B. Metal Bar Grating: A single grating section shall be not less than 1.5 feet or greater than 3 feet in width, or weigh more than 150 pounds.

C. Supports:

1. Same material as grating, except that supports which are to be embedded in concrete shall be Type 316 stainless steel.
2. Coordinate dimensions and fabrication with grating to be supported.

PART 3 EXECUTION

3.01 PREPARATION

A. Electrolytic Protection:

1. Protect aluminum surfaces in contact with dissimilar metals, or embedded or in contact with masonry, grout, or concrete as specified in Section 09901, Protective Coatings.
2. Allow paint to dry before installation of material.

3.02 INSTALLATION

A. Until grating sections are securely fastened in place, area shall be appropriately barricaded or flagged to alert people working in the area of potential fall hazard.

B. Install manufactured products in accordance with manufacturer's recommendations.

C. Install supports such that grating sections have a solid bearing on both ends, and that grating sections will not rock or wobble under design loads.

D. Install grating supports plumb and level as applicable.

E. Install sections of welded frames with anchors to straight plane without offsets.

F. Field locate and install fasteners to fit grating layout.

G. Anchor grating securely to supports using minimum of four fastener clips and bolts per grating section.

H. Each grating or plank section shall be easily removable and replaceable.

I. Completed installation shall be rigid and neat in appearance.

J. Protect painted and galvanized surfaces during installation.

K. Repair damaged coatings as specified in Section 09901, Protective Coatings.

END OF SECTION

SECTION 06220
GLASS-FIBER-REINFORCED PLASTIC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot-Plate Apparatus.
   b. D570, Standard Test Method for Water Absorption of Plastics.
   c. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning Plastics in a Horizontal Position.
   d. D638, Standard Test Method for Tensile Properties of Plastics.
   e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
   f. D696, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 Degrees C and 30 Degrees C.
   g. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   h. D792, Standard Test Methods for Density and Specific Gravity (Relative Density) by Plastics Displacement.
   i. D2344, Standard Test Method for Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short-Beam Method.
   j. D2583, Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
   k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
2. Occupational Safety and Health Act (OSHA): 29 CFR 19.10, Code of Federal Regulations.
3. Underwriters' Laboratories, Inc. (UL): 94, UL Standard for Safety Test for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Catalog information and catalog cuts showing materials, design tasks, and showing load, span, and deflection; include manufacturer's specifications.
   b. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
   c. Grating Supports: Show dimensions, weight, size, location, and anchorage to supporting structure.
2. Samples: Each type of grating.

B. Informational Submittals:

1. Handling and storage requirements.
2. Manufacturer's installation instructions.
3. Manufacturer's Certification of Compliance for specified products.
4. Fabricator's qualification experience.
5. Manufacturer's qualification experience.
6. Independent laboratory test report, dated within 2 years of submittal date, of fire retardant testing conducted on exact type of grating proposed (not a resin test report).

1.03 QUALIFICATIONS

A. Fabricator: Minimum of 5 years' experience.

B. Manufacturer: Minimum of 5 years' experience in manufacturing of products meeting these specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Shipment:

1. Insofar as is practical, factory assemble items provided hereunder.
2. Package and clearly tag parts and assemblies that are of necessity shipped unassembled in a manner that will protect materials from damage, and facilitate identification and final assembly in field.

B. Storage and Handling: In accordance with manufacturer's recommendations and in such a manner as to prevent damage of any kind, including overexposure to sunlight.

PART 2 PRODUCTS

2.01 GENERAL

A. Like Items of Materials: Where possible, provide end products of one manufacturer in order to achieve standardization for appearance, maintenance, and replacement.

B. Unless otherwise specified, all products shall be manufactured by a pultruded process using vinyl ester resin.

C. Products shall be manufactured with ultra-violet (UV) inhibitor additives.

D. Exterior surfaces shall have a synthetic surface veil covering.

E. Furnish molded products as an option where permitted by specifications.

F. Fire Retardance:

1. Flame spread shall be less than 25 as measured by ASTM E84.
2. Include combinations of aluminum trihydrate, halogen, and antimony trioxide, where required to meet fire retardance, in the resin system.
3. Meet self-extinguishing requirements of ASTM D635.

G. Color pigment shall be dispersed in resin system.

H. Fabricate FRP products exposed to outdoor conditions with an additional 1-mil thick UV coating to shield product from UV light.

I. All cut ends, holes, and abrasions of FRP shapes shall be sealed with resin to prevent intrusion of moisture.

2.02 GRATING

A. General:

1. 100 psf minimum, unless otherwise shown.
2. Maximum Deflection: 1/4 inch, unless otherwise shown.

B. Molded Type:

1. Nonskid grit affixed to top of bar surface or a concave, meniscus top to all bars, providing skid resistance.
2. Load bars in both directions with equal stiffness.
3. Square mesh with 1-1/2-inch maximum spacing.

C. Pultruded Type:

1. Main bars joined by cross bars secured in holes drilled in main bars.
2. Cross bars with 6-inch maximum spacing shall mechanically lock main bars in position such that they prevent movement.
3. Intersections: Bond using adhesive as corrosive-resistant as pultrusion resin.
4. Main Bar Ends: Minimum bearing support width of 1-1/2 inches.
5. Skid-Resistant Surface: Grit adhesively bonded, manufacturer's standard.
6. Provide extra stiffness around openings.

D. Hold-Down Clamps: Same material as grating or Type 316 stainless steel.

E. Bolts and Connectors:

1. Corrosion-resistant FRP or Type 316 stainless steel.
2. Size and strength to meet UBC requirements.

F. Fabrications:

1. Field measure areas to receive grating. Verify dimensions of new fabricated supports, and fabricate to dimension required for specified clearances.
2. Section Length: Sufficient to prevent it falling through clear opening when oriented in span direction when one end is touching either concrete or vertical leg of grating support.

G. Manufacturers:

1. Fibergrate Composite Structures, Inc., Addison, TX.
2. IKG/Borden, Clark, NJ.
3. Strongwell Corp., Bristol Division, Bristol, VA or Chatfield Division, Chatfield, MN.
4. International Grating, Inc., Houston, TX.

PART 3 EXECUTION

3.01 GENERAL

A. Install in accordance with manufacturer's written instructions.

B. Install plumb or level, rigid and neat, as applicable.

C. Furnish fasteners and anchorages for complete installation.

D. Seal field cut holes, edges, and abrasions with catalyzed resin compatible with original resin.

3.02 GRATING

A. Anchor grating securely to supports to prevent displacement.

B. Install each grating section such that it is easily removable.

C. Clearance (Grating to Vertical Surfaces): 1/4 inch (plus or minus 1/8-inch tolerance).

END OF SECTION

SECTION 11176
NON-POTABLE WATER SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Non-potable water (NPW) system complete and operational with pumps, strainers, air compressor, motors, hydro-pneumatic tank, control equipment, valves, piping, and accessories as shown and specified.

B. Coordination:

1. Review installation procedures under other Sections and coordinate with the Work related to this Section.
2. Coordinate pumps and motors with electrical work as specified in Division 16, Electrical.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for Work under this section. Include payment in the Lump Sum base Bid Price.

1.03 REFERENCES

A. Reference Standards: Comply as a minimum with applicable provisions and recommendations of the following:

1. American National Standards Institute (ANSI).
2. American Society for Testing and Materials (ASTM).
3. Anti-Friction Bearing Manufacturers Association (AFBMA).
4. Hydraulic Institute.
5. Institute of Electrical and Electronic Engineers (IEEE).
6. National Electric Code (NEC).
7. National Electrical Manufacturers Association (NEMA).
8. Steel Structures Painting Council (SSPC).

1.04 PERFORMANCE REQUIREMENTS

A. Furnish and install the pumps capable of handling water in accordance with these Specifications and as shown on the Drawings.

B. Number of pumps, minimum and maximum operating capacities, TDH, and other pump design data in accordance with Table 11176-B.

C. Pumps shall be designed for continuous operation without cavitation within the specified operating range.

1.05 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 01330, Submittal Procedures.

B. Submit manufacturer's written confirmation that he has carefully examined all of the Procurement Documents in detail, including the arrangement and conditions of proposed structures affecting the performance of the equipment, and the detailed requirements of manufacturing and subsequent installation of the NPW equipment.

C. Submit manufacturer's written confirmation that there are no omissions, ambiguities or conflicts in the Procurement Documents or in the layout drawings that affect the NPW equipment, as shown on the drawings.

D. Submit manufacturer's written confirmation they have reviewed the discharge piping design, the discharge valve locations and types, the air release valve and type, the loads imposed on the pumping unit from the connections, the pump and motor location, the water to be pumped and piping layout, as shown on the plans, and that any incidental modifications thereto will not affect the specified pump and motor performance and efficiency to be furnished under this Contract, and they will be solely responsible for furnishing and delivering pumping equipment that will perform and meet the requirements, as specified in the Procurement Documents.

E. Submit manufacturer's written confirmation that the power required to operate the NPW equipment shall be equal to or less than calculated by the data provided in the Bidder's Proposal.

F. Submit written confirmation by the motor manufacturer that the motors furnished shall operate satisfactorily under all possible operating conditions. The certifications shall be submitted with the motor shop drawings.

G. Submit certified factory test reports.

H. Submit locations of the nearest permanent service headquarters of the NPW equipment submitted.

I. Submit descriptive literature, including a cross-sectional view of each piece of equipment, which indicates materials of construction, weights, principal dimensions and other important details.

J. Submit certified characteristic curves showing the head-capacity relationship, brake horsepower, NPSH requirements, pump efficiency (ratio of the water horsepower to brake horsepower) and pump speed. The curves shall be complete for the entire range of operation from shutoff to minimum head conditions. Submit manufacturer's calculation of radial and thrust bearing L-10 life at the head and flow indicated on the Drawings.

K. If the proposed pumping equipment is supplied with electrical equipment and components of larger capacity than specified or shown on the Contract Documents, the shop drawings for the equipment listed in the following Sections shall be submitted in the same package as the shop drawings submitted for this Section.

1. Section 16111 - Conduit, for conduit related to the submersible wastewater pump only.

L. Record Drawings: Submit record drawing under provisions of Section 01785 - Project Record Documents.

M. Factory Tests: Submit 3 copies of certified test reports to the City Engineer for review.

1. The pump manufacturer shall perform the following inspections and tests on each pump before shipment:
   a. Impeller, motor rating and electrical connections shall first be checked for compliance to the customer's purchase order.
   b. A motor and cable insulation test for moisture content or insulation defects shall be made.
   c. Prior to submergence, the pump shall be run dry to establish correct rotation and mechanical integrity.
   d. Each pump shall be run submerged in water.
   e. After running pump submerged in water, retest motor and cable insulation.
2. If tests do not meet performance specifications, Contractor shall correct deficiencies to provide the specified

performance.

3. A written report stating the foregoing steps have been done must be supplied with each pump at the time of shipment. This report must be approved by the City Engineer prior to payment.

N. Operation and Maintenance Data: Submit operation and maintenance data under provisions of Section 01782, Operations and Maintenance Data.

1.06 QUALITY ASSURANCE

A. All materials used shall be new, of high grade, and with properties best suited to the work required.

B. Manufacturer's Qualifications:

1. NPW equipment provided under this Section shall be a standard product in regular production by manufacturers whose products have proven reliable in similar service for at least 5 years.
2. Manufacturer shall satisfy the City Engineer that it is capable of the following:
   a. Providing local (within 50 miles of the limits of the City of Houston) factory trained personnel to service the pumps and allied equipment when needed within a 48 hour period.
   b. Providing all needed spare parts for the pumps within a 48-hour period.
3. Provide a written manufacturer's certification that spare parts, seals, bearings, O-rings and power cable shall be available locally for models to be supplied.

C. Coordination Responsibility:

1. In order to ensure equipment compatibility, one manufacturer shall be responsible for providing all submersible wastewater pumping equipment, including pump and motor, access frame and guides.

2. The Contractor shall name a factory authorized pump representative/supplier, who will have responsibility for the function of the complete system in accordance with the intent of these Specifications. The named manufacturer shall be experienced in similar work.
3. Contractor shall retain overall responsibility for equipment coordination, installation, testing and operation.

D. Substitution. The engineering design is based on a certain manufacturer's equipment. If the Contractor's choice of equipment is approved but requires modifications to plant, equipment or piping for installation, the Contractor is responsible for submitting revised engineering design and drawings to make the proposed equipment compatible with the project, at no additional cost to the City.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver equipment to site, all store and protect equipment under provisions of Section 01610, Basic Product Requirement.

B. Store all equipment off the ground in enclosed shelter.

1.08 EVALUATION AND SELECTION

A. The City reserves the right to select any equipment which is deemed to be in its best interest.

1.09 WARRANTY

A. Provide warranty under provisions of Section 01770, Closeout Procedures.

PART 2 PRODUCTS

2.01 SEQUENCE OF OPERATIONS

A. The pumping system shall consist of three pumps. The lead pump shall provide pressure and base demand. The lag pump shall run when required to meet demand while maintaining a discharge pressure. The third pump is provided as a standby. A hydro tank will assist with controlling the pump on/off/cycle.

B. The pumps shall automatically alternate. Pump operation/sequencing shall be controlled by the system pressure measured in the hydro-tank. A pressure transmitter shall be provided for the discharge of each pump and shutdown the pump under high pressure conditions.

C. Pressurized air for the hydro-tank shall be supplied by an air compressor. The air compressor cycle will be controlled by a level gauge in the hydro-tank.

D. The pressure set points shall be programmable and changeable by the operator. The anticipated control set points are provided in Table 11176-A.

Table 11176-A: Control Points

Control Points	Discharge Pressure (psi)
All pumps off	90
Lead Pump on	75
Lag Pump on	65
Pump High Pressure Alarm/Shutdown	100

E. The pumps, hydro pneumatic tank and air compressor will be controlled by a single control panel that integrates all the power and process and pump protection controls. The self-backwashing strainers shall be equipped with independent control panels that control and monitor their operation.

F. Number of pumps, minimum and maximum operating capacities, TDH, and other pump design data in accordance with Table 11176-B.

Table 11176-B: Pump Data

Pump Characteristics	**M-581**	**M-582**	**M-583**
Motor Data			
Nominal Size (HP)	60	60	60
Max Speed (RPM)	1,800	1,800	1,800
Solids Passage Min Sphere (in)	0.25	0.25	0.25
Design Capacity (gpm)	400	400	400
Design Head (ft)	380	380	380
Minimum Design Efficiency (%)	80	80	80
Shutdown Head (min ft)	110	110	110
Design $NPSH_A$ (ft)	35	35	35

2.02 PUMPS

A. Manufacturer:

1. Acceptable Manufactures
   a. Flowserve.
   b. Fairbanks-Morse
   c. Goulds.
   d. Approved equal.
2. Listing as an acceptable manufacturer will not relieve the manufacturer from conforming to Contract Specifications.
3. Provide motor driven pumps of the type and speed scheduled. Select pumps that will not overload their motor nameplate horsepower rating, without use of service factor, throughout the full operating range specified. Provide pump connection sizes as drawn.

A. Components

1. Discharge Head:
   a. The discharge head shall be of ASTM A53, Grade B fabricated steel designed for aboveground discharge, with outer shell of sufficient strength and rigidity to support the motor mounted on it.
   b. The discharge head shall have an integral 3-piece segment or smooth elbow type discharge.
   c. The discharge flange shall be faced and drilled to match 150-pound ANSI connections.
   d. The discharge headshaft material shall be 17-4 PH with threaded headshaft couplings.
   e. The stuffing box shall be cast iron and shall contain a minimum of five rings of packing. It shall have a pressure relief connection. The packing gland shall be a 316 SS split type secured in place with non-corrosive studs and nuts. The bearing shall be C89835 bronze. A rubber slinger shall be secured to the shaft above the packing gland.
   f. The design shall permit the shaft to be coupled above the stuffing box.
   g. The bottom face of the discharge head shall be circular and fully finished when tank or barrel mounted.
   h. The diameter and drilling shall match 150-pound ANSI standards.

2. Bowl Assembly:
   a. Pump bowls shall be of close-grained, ASTM A48, Class 30 cast iron.
   b. The suction case and intermediate bowls shall be fitted with replaceable wear rings of bronze ASTM B148 alloy 953. Wear rings shall have the minimum practical clearance to the mating cylindrical surface of the impeller to provide adequate sealing independent of vertical positioning of the impellers.
   c. Bowls and cases shall have bronze sleeve type bushing to support and guide the shaft. Bushing material shall be bronze, ASTM B505 alloy 932.
   d. The suction case shall be belled and its bearings shall be grease packed with provisions for grease circulation from a reservoir in the suction case hub. A sand collar of rubber or bronze, ASTM B505 alloy 838, shall be provided to protect the suction case bearing from abrasives in the liquid pumped.
   e. The intermediate stages shall be selected to provide the maximum efficiency with the least number of stages.
   f. Impeller shall be of the enclosed type, cast aluminum bronze, ASTM B148 alloy 953, accurately cast, machined, balanced and filed for optimum performance and minimum vibration. The design shall be non-overloading for the nameplate rating of the motor specified. The impeller shall be securely fastened to the bowl shaft with keys of ASTM A276, Grade 316 stainless steel or approved equal.
   g. Bowl shaft shall be of sufficient diameter to transmit the pump horsepower with a liberal safety factor and rigidly support the impellers between the bowl or case bearings. The bowl shaft material shall be high-chrome stainless steel of ASTM A582, Grade 416.
3. Column Assembly: Column pipe shall be of ASTM A53, Grade A steel pipe with a minimum wall thickness of 0.375 inches. Steel flanges shall be welded on each end with double fillet welds at each joint.

4. Line shaft shall be of 17-4 PH stainless steel, ground and polished with a surface not to exceed 40 rms. Intermediate shaft section shall be interchangeable and shall not exceed 10 feet in length. The butting ends shall be machined square to the axis of the shaft and face shall be recessed to ensure proper contact. The shaft ends shall be threaded and coupled by 17-4 PH stainless steel couplings designed with a safety factor of 1-1/2 times the shaft safety factor. Threads shall be left hand to tighten during pump orientation.
   Couplings. A flanged adjustable spacer type 4-piece coupling shall be furnished. The coupling shall be steel designed to transmit the required torque and horsepower. The lower half of the coupling shall have a threaded adjusting nut. The upper half shall have a circular key to transmit pump down thrust and a vertical key to transmit torque. The spacer shall be of sufficient length to allow replacement of the mechanical seal without removing the motor.
5. Hardware. All hardware shall be 18-8 stainless steel construction, or approved equal, unless noted otherwise.
6. Motor. Provide a motor as specified in Section 16224. Cooling air circulated through the motor shall discharge upward in a vertical direction.
7. Balance
   a. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excess vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided.
   b. At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8 or more than 1.3. The pump manufacturer shall provide rated critical calculations for approval within the submittal package. All pump assemblies will be field tested to ensure compliance with above critical limitations.
   c. In any case, the unfiltered vibration displacement (peak-to-peak), as measured at any point on the machine, shall not exceed 3 mils.
8. Bearings: All pump and motor bearings shall be rated for a minimum of 100,000 hours of continuous use.

2.03 SELF-BACKWASHING STRAINER

A. The self-backwashing strainers shall be designed and constructed for the conditions summarized in Table 11176-C.

Table 11176-C: Self-Backwashing Strainers

Parameter	Value
Number of Units	2
System Flow Rate (gpm)	800
Strainer Flow Rate (gpm/each)	800
Maximum Operating Pressure (psi)	110
Design Pressure (psi)	200
Operating Temperature (F)	80
Maximum Screen Spacing (in / micron)	.015 / 385
Maximum Allowable Clean Water Pressure Drop (psi)	1.5

B. Manufacturer:

1. Acceptable Manufactures:
   a. Hellan, Model DA.
   b. Amiad, Model SAF.
   c. Eaton/Hayward, Model 2596.
   d. Approved equal.
2. Listing as an acceptable manufacturer will not relieve the manufacturer from conforming to Contract Specifications.

C. Control Panel:

1. Units shall be equipped with a NEMA 4X control panel that controls the automatic backwashing and/or cleaning of the screens.
2. Include a 3 position selector switch (off/on/automatic) to control backwashing cycle.
3. Include contacts for external alarm
4. Pressure switches (diaphragm type) differential pressure switches shall be provided to initiate backwash cycle based on set differential pressure.

D. Body:

1. Constructed of cast iron, ductile iron, or stainless steel.
2. End connections shall be flanged.

E. Screen:

1. Constructed on Type 316 stainless steel
2. V-shape wedge wire.

F. Drain Valve: Electronic actuated valve shall control the backwash flow.

G. General: All components shall be of ASTM designed materials.

2.04 HYDRO PNEUMATIC TANK

A. The hydro pneumatic tank shall be designed, constructed, and stamped in accordance with the latest edition of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 for the conditions summarized in Table 11176-D.

Table 11176-D: Hydro Pneumatic Tank

Parameter	Value
Total Volume (gallons)	3,720
Maximum Operating Pressure (psi)	125

B. Tank manufacturer shall have been in the ASME Vessel manufacturing business for a minimum of five (5) years.

C. The tank manufacturer is to supply all and any items welded to the tank. Any items or components screwed or bolted to the tank are to be supplied by the vessel installer. Prior to delivery, the Manufacturer shall furnish to the City two copies of Form U-1/U-1A, Manufacturer's Data Report for Pressure Vessels.

D. The tank shall have appurtenances as shown on the Plans and specified herein. These connections and appurtenances shall include but not be limited to the following:

1. An ASME nameplate must be permanently attached to the tank.
2. A 12'x16" (minimum) access manhole with cover and gasket shall be provided the size and location as shown on the plans.
3. The tank will be provided with a drain the size and location as shown on the plans.

4. The tank shall be fitted with inlet/outlet connections the size and location as shown on the plans.
5. Threaded nozzles shall be 3,000 pound for sight glass assembly, probes, air supply, and pressure relief valves.
6. Set of lifting lugs.
7. Sight glass and pressure gauge as specified elsewhere in these specifications.
8. Steel saddles shall be provided with the tank and installed on foundations as shown on the plans.

E. All flanges shall be 150# standard type ANSI B16.5, raised face type, forged of Specification SA-105 steel.

F. All screwed couplings shall be 3000# half or full couplings of forged carbon steel meeting Specification SA-105.

G. Do not provide coupling at center of heads. Weld fabrication holes in each head up as per the Code and grind flush inside and out.

H. If required, the tank manufacturer shall utilize spot radiography on the Head to Shell girth weld and spot radiography on the Shell to Shell girth welds all fully meeting the afore stated codes.

I. The tank manufacturer shall calculate thickness of the steel to withstand the highest expected working pressure with a safety factor on both Heads and Shell as required by the most current edition of the ASME Code.

J. The tank manufacturer shall calculate the Shell thickness so as not to have internal or external stiffener rings.

2.05 AIR COMPRESSOR

A. The non-lubricated air compressor shall be designed and constructed for the conditions summarized in Table 11176-E.

Table 11176-E: Air Compressor

Parameter	Value
Maximum Pressure (psi)	125
Air flow rate at Maximum Pressure (cfm)	2.5
Receiver Volume (gallons)	30
Motor (hp)	5

B. Manufacturers:

1. Acceptable Manufactures:
   a. Ingersoll Rand.
   b. Champion.
   c. Approved equal.
2. Listing as an acceptable manufacturer will not relieve the manufacturer from conforming to Contract Specifications.

2.06 GATE VALVES

A. Gate valves 4 inches through 14 inches: Solid wedge type, with resilient nitrile rubber (Buna- N) tapered seat. Provide valves complying with AWWA C-509. Acceptable manufacturers include Mueller, M&H, AVK, or approved equal.

B. Gate valves 16 inches and larger: Solid wedge type with bronze to bronze seating surface. Provide valves complying with the AWWA C-500. Acceptable manufacturers include Mueller, M&H, AVK, or approved equal.

C. Supply gate valves rated as 200 psi water working pressure with 400 psi hydrostatic test for structural soundness for 2 inches through 12 inches and 150 psi water working pressure with 300 psi hydrostatic test for structural soundness for sizes 14 inches through 30 inches.

D. Stems: OS&Y rising type manganese bronze having a minimum tensile strength of 60,000 psi, a minimum yield strength of 20,000 psi for valve sizes through 24 inches, and a minimum tensile strength of 80,000 psi, a minimum yield strength of 32,000 psi for valve sizes 30 inches and larger.

E. Valve Bodies: Cast iron conforming to ASTM A126 or ASTM A395. Fabricate internal trim parts of 300 series stainless steel.

2.07 AIR RELEASE AND AIR AND VACUUM VALVES

A. Air Release and Air and Vacuum Valves: Provide when shown on Drawings.

B. Air Release Valve Design: Single float, single orifice, float operated with a compound lever mechanism to automatically release accumulated air and gases while the system is pressurized and operating.

C. Air and Vacuum Valve Design: Two float where the top float shuts off against the seat due to the lifting force of the bottom float as liquid enters the valve body. Once closed and pressurized the air and vacuum valve will not open to release air.

D. Fabricate valve body, cover and baffles of ductile iron. Fabricate internal metal parts of stainless steel. Make valve seat of Buna-N nitrile rubber.

E. Fit valve with blow off valves, quick disconnect couplings and minimum 6-feet of hose to permit back flushing after installation with dismantling valve.

F. Provide Series 50 ARV by APCO air release valves or equal.

G. Provide Series 143C CAV by APCO air and vacuum valves or equal.

2.08 CHECK VALVES

A. Swing check valves 4-inches through 14-inches having a system pressure 30 psi or less, shall be air cushioned with side mount lever and weight. The valve shaft shall extend through both sides of the body with minimum shaft diameters equal to APCO Series 6000. The cushion shall be totally enclosed, swivel mounted at the bottom, and equipped with a micrometer air control valve and air breather filters. Valves shall be similar to APCO Series 6000, or approved equal.

B. Swing check valves 10-inches through 14-inches having a system pressure greater than 30 psi shall be cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, or approved equal.

C. Swing check valves 16-inches and larger regardless of system operating pressure shall be cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, or approved equal.

D. Check valves of special design utilizing controlled closing of the disc, such as APCO Series 6000B (Bottom-Buffer) and Golden Anderson Fig. #25-DXH or approved equal shall be used when specifically indicated on the Drawings. These valves are special valves used to control the surge pressure in the force main upon multiple pump shutdown during a power failure. Other surge control check valves utilizing ball or cone valve and power cylinder operator may also be used as approved by the City Engineer.

E. All check valves shall have 300 series stainless steel hinge shafts, stainless steel body seats and stainless steel resilient seat retainer rings.

2.09 PIPING

A. Ductile Iron Pipe: AWWA C151, Class 53 minimum.

1. Fittings: AWWA C110
2. Joints: AWWA C115, with threaded flanges and rubber gaskets.
3. Bolts, studs and nuts: ASTM A-316 stainless steel.
4. Flanges: Same material as pipe and screwed onto the pipe in accordance with ANSI B16.1. Use screwed-on flanges attached to the pipe by the pipe manufacturer or pipe manufacturer's authorized fabricator.
5. After flange attachment, have flange and pipe re-faced so that the end of the pipe is even with the face of the flange and both are perpendicular to the axis of the pipe.
6. All flanged joints shall be hydrostatically tested after fabrication to a pressure rating of 300 psi minimum. All flanged joints shall be marked (Tested at 300 psi) and notarized certification papers supplied to the purchaser.
7. Align bolt holes on both flanges at the end of each piece of pipe.
8. Where cap screws or stud bolts are required, incorporate tapped holes for such cap screws or stud bolts in the flanges.
9. Interior Lining: Use one of the following interior lining systems.
   a. Cement lining complying with AWWA C104.
10. Exterior Coating: Coat pipe in accordance with Section 09901, Protective Coatings.
11. Performance: Use pipes and fittings designed for an internal working pressure range of -10 to +150 psi.

B. Wall Pipes: Ductile iron flanged with water stop collar.

1. Ductile iron water stop collar to be welded on the wall pipe prior to installation of the interior lining.
2. Interior Lining: As specified for pipe in paragraph 2.01A.9.
3. Bolts, studs and nuts: Type 316 stainless steel.

C. Flanged Coupling Adapter:

1. Type: Ductile iron; Romac Industries, Style FCA501, Dresser Style 128, or approved equal.
2. Interior Lining: As specified for pipe in paragraph 2.01A.9, or heat-fused epoxy coating complying with AWWA C213.
3. Bolts, studs and nuts: Type 316 stainless steel.

D. Grooved Couplings: Grooved couplings conforming to AWWA C606 may be used for exposed piping outside of the wet well.

1. Manufacturers: Gustin-Bacon, Victualic Style 31 (flexible or rigid).
2. Bolts and Nuts: Type 316 Stainless Steel.
3. Gaskets: Flush seal type, compatible with the fluid, according to the manufacturer's recommendations.
4. Pipe Wall Thickness: Wall thickness of grooved piping shall conform to the coupling manufacturer's recommendations to suit the highest expected pressure.
5. Equipment Connections: Equipment connections shall be rigid-type grooved couplings unless thrust restraint is provided by other means.
6. Require the manufacturer to verify correct choice and installation of couplings, gaskets, and workmanship to assure correct installation.

E. Air Release Piping: Schedule 40, ANSI B36 stainless steel with ANSI B1.20.1 threaded joints.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation of the NPW equipment shall conform to the manufacturer's instructions and recommendations and reviewed shop drawings.

B. Check dimensions shown on the Drawings prior to installation of Work. Notify the City Engineer promptly of any conflicts or errors.

C. Run pipe lines straight and true in alignment, grade and location as shown on the Drawings.

D. Install piping through walls and floors as shown on the Drawings.

E. Install valves and specialties in accordance with manufacturer's written instructions to permit intended performance.

F. Support and anchor valves and gates in accordance with Section 15140, Pipe Hangars, Supports and Restraints.

G. Pump:

1. Install pumps in accordance with manufacturers printed instructions.
2. Provide access space around pumps for service. Provide no less than minimum recommended by manufacturer.
3. Ensure pumps operate at specified fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
4. Provide drains for seals, piped to and discharging into nearest floor drains.
5. Lubricate pumps before start-up.
6. Noise vibration, alignment and balancing requirements in other sections of Division 15 apply to pumps and motors specified in this section.

3.02 PIPE IDENTIFICATION LABELS

A. Label piping as follows:

1. Identify all piping with plastic sleeve snap-on markers equivalent to Seton Name Plate "Setmark" or approved equal with 3/4-inch letters on pipe sizes to 4-inch and 2-inch letters on pipe sizes 5-inches and larger, or approved equal.
2. Locate at each valve, each branch take-off, and at each side of floor or wall through which pipe passes.
3. Not more than one label is required every 12 feet if adjacent label is visible.
4. Place labels on all lines.

3.03 Piping Testing

A. Flush pipes clean. Tighten connections to stop any visible leaks.

B. Test piping in accordance with Section 4-Hydrostatic Testing, AWWA C600.

C. Test piping to a pressure of 150 percent of the maximum possible discharge pressure of the pumps.

3.04 Pump Testing

A. Factory Test:

1. Material and equipment shall be subject to inspection and tests at the place of manufacture and after installation. Final acceptance shall be based on field tests. The Testing Code of the Latest Standards of the Hydraulic Institute shall be followed in making the hydraulic tests.
2. The City reserves the right to witness the factory tests. Travel costs for one City representative to witness test shall be paid by City for the first test. If the test fails or does not take place on scheduled date, then cost will be reimbursed by Contractor. The Contractor shall notify the City at least fourteen (14) days prior to the factory test.
3. Submit three (3) copies of certified factory test reports to the Owner for review.

B. Field Tests:

1. The Contractor/Manufacturer shall make preliminary field tests to determine compliance with the specifications within time of completion. When such tests demonstrate compliance, the official tests will be run.
2. Upon completion of the installation and after satisfactory preliminary field tests, the pumps, valves and appurtenances shall be tested under the supervision of the Contractor/Manufacturer and will be witnessed by the Owner to demonstrate compliance with all the contract requirements and guarantees. All equipment necessary for preliminary and field testing and the costs involved shall be borne by the Contractor/Manufacturer, including the services of the equipment manufacturer's engineer and expenses incident to retests, if any, occasioned by defects and failure of equipment to meet contract guarantees at the first tests. Water, electric current, water level indicators and recorders, flow meters, observers for taking readings, gauges, and connections for measuring the heads on the pumps shall be provided by the Contractor/Manufacturer. It is expected that the field tests results (head, capacity, efficiency) shall be approximately equal to the results obtained by the shop test. Any defects disclosed in the equipment by those tests shall be made good by the Contractor/Manufacturer or the equipment replaced by him without additional cost to the Owner. Tests after installation shall include the following:
   a. Operating tests in service shall be given to all the NPW equipment.
   b. The alignment of each pump, shafting and motor unit shall be proven straight and plumb and the satisfactory operation of each pump unit shall be demonstrated before the official test.
   c. Performance and efficiency tests of the pumps shall include tests to prove the guaranteed capacity and efficiency of each pump at rated conditions and shall be made after the pumping units have operated satisfactorily under normal operating conditions for at least 100 hours, and shall include:
      1) Capacity and overall efficiency - The work done by the unit shall be determined by multiplying the total weight of water pumped figured at 62.4 lbs. per cu. ft. by the average total head. The overall efficiency shall be the ratio of the total

work done to the power input to the motor, both expressed in like units. The quantity of water pumped will be measured by flow meters installed downstream of the pumping units.

2) Total Head - Readings simultaneous with the capacity readings shall be taken of the head in feet as determined by measuring the distance from the water level in the suction well to the centerline of the discharge gauge plus the gauge reading. Proper credit will be allowed for the velocity head.

3) Power input - Reading simultaneous with the capacity readings and total head readings shall be taken of the power input to the motor as determined by calibrated polyphase watthour meters or wattmeters to be located on the switchgear.

4) Accuracy of efficiency - The field test efficiency shall be within 2 points of the guaranteed efficiency at rated capacity and head. The 2 points allowable differential is to cover estimated deficiencies on flow, pressure and power measurements for testing.

5) Submit three (3) copies of certified field test reports to the Engineer for review.

3. Acceptance test shall be the field test conducted at the pump installation site, and not the factory test.

C. Start-up Data: Contractor shall complete and submit the start-up records and maintenance data sheets.

3.05 PAINTING

A. Paint pipes, valves, and equipment in accordance with Section 09901, Protective Coatings.

END OF SECTION

SECTION 11212
VERTICAL TURBINE PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
2. American Petroleum Institute (API):
   a. 610, Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries.
   b. 670, Machinery Protection Systems.
3. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A536, Standard Specification for Ductile Iron Castings.
   c. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
4. Hydraulic Institute Standards (HIS):
   a. 9.6.4, Rotodynamic Pumps for Vibration Measurements and Allowable Values.
   b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
5. National Electrical Manufacturer’s Association (NEMA): MG 1, Motors and Generators.
6. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions.
4. Calculations:
   a. Torsional analysis for complete rotating assembly. Analysis report shall include the specific items of API 610, Part 2.8, Dynamics.
   b. Lateral vibration analysis for discharge head motor assembly and for column pipe bowl assembly.
5. Reverse Runaway Speed: Pump manufacturer's estimated maximum reverse runaway speed for pump and motor assembly. Submit coincident reverse flow and pump head for speed estimates.
6. Pump maximum downthrust or upthrust in pounds.
7. Detailed structural, mechanical, and electrical drawings showing equipment dimensions, size, and locations of connections and weights of components.
8. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, parts nomenclature, and materials of construction lists.
9. Baseplate drawings with leveling jackscrew details, anchor bolt and sleeve details, and minimum foundation installation and leveling requirements.
10. Power and control wiring diagrams, including terminals and numbers.
11. Complete motor nameplate data, as defined by NEMA, motor manufacturer, including motor modifications.
12. Factory finish system.
13. Vibration monitoring system information including technical product bulletins and descriptions, specification data sheets, wiring diagrams, communications hardware and software, documentation sufficient for configuration of functions specified herein and shown on Drawings.
14. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section XX, that factory finish system is identical to requirements specified herein.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's printed installation instructions.
5. Factory Functional and Performance Test Reports. Factory test data for each pump shall be submitted, reviewed, and approved by Engineer prior to shipment of equipment.
6. Suggested spare parts list to maintain equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
7. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 EXTRA MATERIALS

A. Furnish for Three set of pumps**:**

1. Complete set packing.
2. Complete set bearings.
3. Complete set gaskets and O-ring seals.
4. Complete set of shaft sleeves.
5. Complete set keys, dowels, pins, etc.
6. Complete mechanical seal.
7. Impeller.
8. Impeller shaft.
9. Impeller wear ring.
10. Bowl wear ring.
11. Head shaft.
12. One complete set of special tools required to dismantle pump.

PART 2 PRODUCTS

2.01 GENERAL

A. Lateral and Torsional Vibrations:

1. Pump and motor assembly shall have no natural frequencies within 20 percent of operating speed range.
2. Fundamental critical speed of rotating assembly shall be no less than 50 percent above the rated speed.
3. Pump manufacturer shall conduct an analysis of the lateral and torsional vibration of pump and motor assembly.
   a. Excitation frequency range of the analysis shall include, but not be limited to, number of motor poles and number of impeller vanes.
   b. Perform detailed stress analysis for pump, coupling, motor system at each critical speed, and steady-state operating condition.
   c. Stress analysis shall demonstrate that in no case shall maximum stress on pump, coupling and motor component exceed endurance limits of pump, coupling and motor assembly components materials of construction

B. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

B. No “or-equal” or substitute products will be considered.

2.03 SHAFT SEALS

A. Sealing system for vertical turbine pump shafts shall be mechanical seal or packed stuffing box as indicated in pump data sheet.

B. Mechanical Seal Requirements:

1. Nonfretting type requiring no wearing sleeve for shaft.
2. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through seal area.
3. Split Type:
   a. Requiring no field assembly other than assembly around shaft and insertion into pump or balanced cartridge design in conjunction with a spool type spacer coupling as specified in pump data sheet.
   b. Nonshaft O-rings: Ball and socket type requiring no gluing.
   c. Initial seal installation at factory shall be with nonsplit seal faces; spare seals and spare kits to have split faces.
   d. Unless otherwise specified, capable of 400 psig service, be self-aligning, self-centering, and single.
   e. Manufacturer and Product: A.W. Chesterton Company; No. 442.
4. Arrangement shall allow removal of seal without disturbing pump or driver.
5. For clear water services and solids up to 5 percent by weight, face combination shall be hard/soft. Otherwise, hard/hard faces shall be used.
6. Design such that dynamic O-ring moves towards a clean surface as face wears and springs are not in pumped fluid.
7. Stationary seal face shall be spring loaded to provide self-aligning despite stuffing box misalignment.
8. Where cartridge type mechanical seals are specified:
   a. Single, balanced, flexible stator design.
   b. Capable of 600 psig service.
   c. O-ring secondary seals and setscrew drive with three-point centering to ensure 0.003-inch maximum perpendicularity of rotary face to shaft.
   d. Gland shall have flush port and be affixed to equipment with adjustable tabs to fit irregular bolt patterns.
   e. Manufacturers and Products:
      1) A.W. Chesterton Company; 155.
      2) Crane; 1B.
9. Seal Materials:
   a. Metals:
      1) Loaded Parts Over 0.060-inch Cross Section: Type 316 stainless steel minimum.
      2) Thinner Parts (springs): Hastelloy-C, Alloy 20, AMS5876 Elgiloy, or other alloy that is not vulnerable to chloride stress corrosion.
   b. Elastomers: Fluorocarbon Viton preferred, unless seal manufacturer recommends ethylene propylene for service conditions.

c. Faces: Homogeneous construction. Surface treatments and plated faces are unacceptable.
   1) Acceptable hard faces include nickel bound tungsten carbide, self-sintered silicon carbide, reaction bonded silicon carbide, or graphitized silicon carbide. Silicon carbide is preferred because of its higher pressure-velocity capability.
   2) Acceptable soft face is carbon-graphite, either Union Carbide 658RC or Purecarbon P8412.

10. Seal Environmental Controls:
   a. Pipe seal flush port drain to wetwell or hub drain as shown on Drawings with 1/8-inch orifice plate in the line. Provide venting of seal chamber.
   b. Mechanical seals for anything other than clear water services shall be fitted with Enviroseal SpiralTrac Version F, N, or D, installation Type I as recommended by A.W. Chesterton Company.
      1) Provide fluid circulation in seal chamber that removes frictional heat from mechanical seal.
      2) Convey particulate matter and contaminants for removal by conveying them from bore to shaft by means of integral machined spiral.
      3) Remove particulate matter from seal chamber, without seal flush water, through integral machined exit groove.
   c. Material of Construction: Type 316 stainless steel.
   d. Connect mechanical seal to water purge supply where indicated on Drawings.

C. Packing Requirements:

1. Stuffing Box:
   a. Tap to permit introduction of seal liquid.
   b. Hold a minimum of five rows of packing and a lantern ring.
   c. Face attached.
   d. Box and shaft shall be suitable for field installation without machining or other modifications of mechanical seal specified herein for applicable pump and operating conditions.
2. Packing Rings:
   a. Three asbestos free die-molded packing rings of braided graphite material free of PTFE.
      1) A.W. Chesterton Company; 1400R for nonpotable water services.

b. Three die-molded rings of braided PTFE material.
   1) A.W. Chesterton Company; 1725 that is NSF/ANSI 61 acceptable for potable water services.
c. Glands:
   1) Two-piece split construction.
   2) Fit impeller end of packing with A.W. Chesterton Company; Enviroseal SpiralTrac, Version P, packing protection.

3. Where pumped fluid is clear water:
   a. Pump discharge run through 1/8-inch orifice for packing lubrication. Otherwise, provide seal water flow control and monitoring as detailed on Drawings.
   b. External Seal Water Flow: 5 gallons to 30 gallons per hour flow rate, plus or minus 10 percent accuracy.
   c. Manufacturer and Product: A.W. Chesterton Company; SingleFlow.
4. Shaft Sleeve:
   a. Fit section of shaft or impeller hub that extends through or into stuffing box with replaceable stainless steel sleeve with a Brinell hardness of not less than 500.
   b. Sleeve shall be held to shaft to prevent rotation.
   c. Gasketed to prevent leakage between shaft and sleeve.
   d. Thickness: 3/8 inch minimum.

2.04 [A: VIBRATION [B: AND TEMPERATURE] [C: TRANSDUCERS] [D: AND] [E: MONITORING SYSTEM]

A. General:

1. Meet requirements specified herein and with motor temperature and vibration sensors specified in Section **[A: 26 20 00, Low-Voltage AC Induction Motors] [B: 26 19 00, Medium-Voltage AC Induction Motors]**.
2. Provide temperature and vibration monitoring systems in cabinet as shown in Process and Instrumentation Diagram (P&ID), program, test, calibrate, fully configure and place into operation.

B. Features:

1. Microprocessor based system with programmable firmware options.
2. Programmable operating range.
3. Programmable alarm delays.
4. Four-channel modules.
5. AND or OR danger voting logic.
6. Timed OK/Channel defeat.

7. Ethernet and serial communication interface selections to plant control system.
8. Include 7-position or 14-position slot rack(s) which shall contain the following types of plug in modules:
   a. Power supply module.
   b. Rack interface module.
   c. One or more radial vibration velocity monitoring module as required.
   d. One or more thrust (axial) vibration velocity monitoring module as required.
   e. One dual channel phase reference (timing) monitoring module.
9. Interconnected to each other and to remote terminal unit (RTU) via ethernet or serial communications as required. This communications link shall effectively communicate data relevant to operating purpose of vibration monitoring systems. Provide data configuration software and documentation to allow communication with RTU.
10. Configure alarm contacts to be normally closed, open in alarm condition and open on loss of power.
11. Cables requiring special calibration for optimum performance shall be calibrated by the Bently Nevada Corporation or an authorized representative thereof.
12. Manufacturer and Product: Bently Nevada Corporation; 3500 Series.

C. Bearing Housing Vibration Velocity Transducers:

1. Permanently installed accelerometers by pump manufacturer.
2. Located at top flange of discharge head.
3. Two radial velocity transducers shall be provided with one measuring discharge nozzle direction and one at 90 degrees to discharge nozzle direction.
4. Elements:
   a. Accelerometers, providing inches per second RMS (root mean squared) velocity output.
   b. Minimum Rated Operating Frequency: Less than minimum pump operating speed.
   c. Vibration element shall include shielded signal cable and be enclosed in NEMA 4X housing.

D. Bearing Temperature Elements:

1. Permanently installed by motor manufacturer.
2. Sensor shall be as specified in Section **[A: 26 20 00, Low-Voltage AC Induction Motors] [B: 26 19 00, Medium-Voltage AC Induction Motors]**.

E. Motor Casing Velocity Transducer: As specified in Section **[A: 26 20 00, Low-Voltage AC Induction Motors] [B: 26 19 00, Medium-Voltage AC Induction Motors]**.

F. Vibration and temperature transducers shall be installed in accordance with guidelines provided by API 670.

G. Provide terminal junction box mounted on pump discharge head. Provide conduit and cable from pump vibration transducers to terminal junction box.

2.05 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. Anchor Bolts: **[A: Galvanized,] [B: Type 316 stainless steel,] [C: sized by equipment manufacturer,] [D: 1/2-inch minimum diameter,]** and as specified in Section 05 50 00, Metal Fabrications. **[E: Coat in accordance with Section 09 90 00, Painting and Coating.]**

2.06 FACTORY FINISHING

A. Prepare and prime **[A: , and finish]** coat in accordance with **[B: Section 09 90 00, Painting and Coating] [C: Manufacturer's standard [D: baked] enamel finish]**.

2.07 SOURCE QUALITY CONTROL

A. **[A: Factory Inspections:]** Inspect **[B: control panels] [C:]** for required construction, electrical connection, and intended function.

B. **[A: Factory Tests and Adjustments:]** Test **[B: one] [C:] [D: all] [E: equipment] [F:] [G: and] [H: control panels [I: actually] [J: identical to that]]** furnished.

C. Factory Test Report: Include **[A: test data sheets,] [B: curve test results,] [C: performance test logs,] [D: certified correct by a registered professional engineer]**.

D. Functional Test: Perform **[A: manufacturer's standard,] [B:] [C: motor] test on [D: equipment] [E:]. [F: Include vibration test, as follows:**

1. **Dynamically balance rotating parts of each [G: pump] [H:] and its driving unit before final assembly.**

2. **Limits:**
   a. **Driving Unit Alone: Less than [I: 80] [J:] percent of NEMA MG 1 limits.**
   b. **Complete Rotating Assembly Including [K: Coupling,] [L: Drive Unit,] [M: ,] [N: and Motor:] Less than [O: 90] [P:] [Q: percent] [R: of limits established in the Hydraulic Institute Standards.] [S:]]**

E. Performance Test:

1. Conduct on each pump at rated speed.
2. Perform under simulated operating conditions.
3. Test for a continuous **[A: 3-hour] [B:]** period without malfunction.
4. Test Log: Record the following:
   a. Total head.
   b. Capacity.
   c. Horsepower requirements.
   d. Flow measured by factory instrumentation and storage volumes.
   e. Average distance from suction well water surface to pump discharge centerline for duration of test.
   f. Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.
   g. Calculated velocity head at the discharge flange.
   h. Bowl head.
   i. Driving motor voltage and amperage measured for each phase.
5. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards if necessary.

F. Motor Test: See Section **[A: 26 20 00, Low-Voltage AC Induction Motors] [B: 26 19 00, Medium-Voltage AC Induction Motors]**.

G. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that driving units are properly aligned, plumb, and level with driven units and interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, nonshrinking grout of the proper category, as specified in Section 03 62 00, Nonshrink Grouting. Remove wedges after grout is set and pack void with grout.

E. **[A: Vibration and Temperature Transducers:**

1. **Install in accordance with API 670.**
2. **Install two terminal junction boxes mounted on motor housing.**
3. **Install conduit and cable from motor bearing temperature transducers to one of the terminal junction boxes. Install conduit and cable from motor vibration transducers to the other junction box.]**

F. Connect suction and discharge piping without imposing strain to pump flanges.

G. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

A. As specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Vibration Test:
   a. Test with unit installed and in normal operation, and discharging to connected piping systems at rates **[A: between low discharge head and high discharge head conditions specified,] [B:] [C: and with actual building structures and foundations provided]** shall not develop vibration exceeding **[D: 80 percent] [E:]** of limits specified in HIS 9.6.4.
   b. If unit exhibits vibration in excess of limits specified, adjust or modify as necessary. Unit that cannot be adjusted or modified to conform as specified shall be replaced.

3. **[F: Flow Output: Measured by plant instrumentation and storage volumes.]**
4. **[G: Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.]**
5. Test for continuous **[H: 3-hour] [I:]** period.
6. Test Report Requirements: In accordance with HIS 14.6.

B. Performance Test: In accordance with Hydraulic Institute Standards.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection]**.
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.
5. **[M:]** person-days for post-startup training **[N: of Owner's personnel]**. **[O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

B. See **[A: Section 01 43 33, Manufacturers' Field Services] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup.]**

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Pump Data Sheet.

END OF SECTION

VERTICAL TURBINE PUMP DATA SHEET, 44 42 56.03-_____

Tag Numbers: _____

Pump Name: _____

Manufacturers and Product: (1) Flowserve Worthington

(2) Fairbanks Morse

(3) Weir Floway

(4) ITT Goulds Pumps

(5) Sulzer Johnston

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): _____

Pumping Temperature (Fahrenheit): Normal _____ Max _____ Min _____

Specific Gravity at 60 Degrees F: _____ Viscosity Range: _____

[A: Vapor Pressure at 60 Degrees F: _____.] pH: _____

Abrasive (Y/N): _____Caused by: _____

Possible Scale Buildup (Y/N): _____ Caused by: _____

Corrosive (Y/N): _____ Caused by: _____

[B: Total suspended solids (mg/L) _____.]

[C: Largest diameter solid pump can pass (inches) _____.]

Min. NPSH Available (Ft. Absolute): _____

[D: Suction Pressure (Ft): Max _____ At Rated Capacity _____.]

Altitude (Feet above Mean Sea Level): _____

Area Classification: _____

Ambient Temperature (degrees F.): _____

Location: Indoor (Y/N): _____ Outdoor (Y/N): _____

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: _____ **[A: Secondary: _____]**

Total Dynamic Head (Ft): Rated: _____ **[B: Secondary: _____]**

BHP at Rated Point: _____ **[C: Secondary: _____]**

[D: Maximum Shutoff Pressure (Ft): _____]

Min. Pump Hydraulic Efficiency at Rated Capacity (%): _____

Max. NPSH Required at **[E: Rated] [F: Secondary]** Capacity (Ft. Absolute): _____

Max. Pump Speed at Rated Capacity (rpm): _____

Constant (Y/N): _____

Adjustable (Y/N): _____

[G: Reverse Rotation: Pump shall be capable of operating at runaway speed in reverse rotation without damage.]

[H: wk2 inertia of total rotating assembly (pump + motor components) lb-ft2, minimum: _____]

DESIGN AND MATERIALS

Pump Type: **[A: Open Line Shaft (Y/N) ___] [B: Enclosed Line Shaft (Y/N) ___]**

Bowl: _____ **[C: Bowl Wear Rings: _____] [D: Bowl Lining: _____] [E: Bowl and Suction Bell Maximum Diameter (inches): _____]**

Bowl Bearings: _____

Column: _____ **[F: Column Lining: _____]**

Line Shafting: _____ **[G: Max. Bearing Span (Feet): _____]**

Line Shaft Bearings: **[H: Fluted synthetic rubber with bronze, ASTM B584 C90500, shells] [I:]**

Discharge Head:

Type: _____

Material: **[J: Fabricated Steel, ASTM A36/A36M] [K: Cast Ductile Iron, ASTM A536, Grade 60-40-18]**

Discharge Nozzle Size (inches): _____ Flange Standard/Class: _____

[L: Plain End (Y/N): _____] [M: Thrust Tie Lugs (Y/N): _____]

[N: Suction Can (Y/N): _____] [O: Can Nominal Diameter (Inches): _____] [P: Can Material: _____] [Q: Suction Can Bottom Elevation and Suction Nozzle Location as Shown on Drawings. See Remarks below.]

Impeller:

Type: _____

Material: _____

[R: Impeller Wear Rings: _____]

Head Shaft Material: _____ Shaft Sleeve Material: _____

Shaft Sealing: Packing (Y/N) _____ Mechanical (Y/N) _____

Type: **[S: Split] [T: Cartridge] [U: O-ring (Y/N) _____]**

Seal Lubrication: _____

Coupling: Falk (Y/N) _____ Fast: (Y/N) _____ Spring-Grid (Y/N) _____

Gear Type (Y/N) _____ Spacer (Y/N) _____

Manufacturer Standard (Y/N) _____

Baseplate Material: _____

[A: Sole Plate (Y/N) _____ Material _____] [B: Soleplate: Provide for support of pump assembly, including thrust and dynamic loads, as indicated. Top of soleplate shall be faced, drilled, and tapped for pump baseplate.]

Motor Base Material: _____

DRIVE MOTOR (See Section **[A: 26 20 00, Low-Voltage AC Induction Motors] [B: 26 19 00, Medium-Voltage AC Induction Motors]**.)

Horsepower: _____ Voltage: _____ Phase: _____

Synchronous Speed (rpm): _____

Service Factor: _____

Motor nameplate horsepower shall not be exceeded at any head-capacity point on pump curve.

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____ TEWAC _____ WPI _____ WPII _____

Mounting Type: Vertical Hollow Shaft _____ Nonreverse Ratchet (Y/N) _____

Vertical Solid Shaft _____

ABMA 9 and ABMA 11, B-10 Motor Bearing Life (hrs): _____

[C: Adjustable Speed Drive Range: _____ min to _____ max. See Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems.]

REMARKS **[A: Provide 1/2-inch pressure tap from discharge head base to suction can for field installation of a vent valve and pressure gauge. See Drawing detail.]** _____

_____

_____

_____

SECTION 11305
SUBMERSIBLE PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 150.
3. ASTM International (ASTM):
   a. A48, Standard Specification for Gray Iron Castings.
   b. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
4. Hydraulic Institute Standards (HIS):
   a. 11.6, Submersible Pump Test.
   b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
5. National Electrical Manufacturers Association (NEMA).
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.
7. Underwriters Laboratories Inc. (UL).

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to ratings and nomenclature of Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction, including cable seal details.

3. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump, from shutoff to maximum capacity. Indicate separately head, capacity, horsepower demand, overall efficiency, and minimum submergence required at guarantee point.
4. For variable speed motors, provide variable speed curves for every 50 rpm over the operational range.
5. Power and control wiring diagrams, including terminals and numbers.
6. Motor data, in accordance with the requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
7. Adjustable frequency drive data, in accordance with the requirements of Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.
8. Factory-finish system.
9. L-10 bearing life calculations per ABMA.
10. If required, wiring for motor protection module.

B. Informational Submittals:

1. Special shipping, storage and protection, and handling instructions.
2. Manufacturer's printed installation instructions.
3. Factory and Field Performance Test Reports and Log**.**
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements**,** that factory finish system meets requirements specified herein.
5. Suggested spare parts list to maintain equipment in service for period of 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
7. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
8. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 EXTRA MATERIALS

A. Furnish for each pump:

1. One set mechanical seals.
2. One complete set of special tools required to dismantle pump.

PART 2 PRODUCTS

2.01 GENERAL

A. Submersible, vertical shaft, centrifugal nonclog type, for pumping wastewater.

B. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.

C. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.

D. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

E. Pumps furnished under this section to be provided by a single manufacturer.

2.02 SUPPLEMENTS

A. Specific requirements are attached to this section as supplements.

2.03 COMPONENTS

A. Equipment consists of pump complete with motor, control system, guide rail, anchoring brackets, base elbow, power cable, and pump lifting cable and control panel and level switches.

B. Characteristics:

1. Motor and rotating parts shall be removable from motor end of pump.
2. Mating surfaces to be watertight and fitted with nitrile O-rings.
3. Pumps fitted with dynamically balanced nonclog impellers designed to pass course solids and stringy materials.

C. Lifting Arrangement:

1. Stainless steel chain, 2 feet minimum, and one “grip-eye.”
2. Attach chain permanently to pump and access platform with stainless steel wire rope.
3. “Grip-eye” capable of being threaded over and engaging links of stainless steel chain so pump and motor may be lifted with “grip-eye” and independent hoist.

D. Sliding Guide Bracket:

1. Integral part of pump unit.
2. Pump unit to be guided by no less than two guide bars, or equivalent cable system, and pressed tightly against discharge connection elbow with metal-to-metal contact or through use of profile-type gasket, provided gasket is attached to pump's flange and can be easily accessed for inspection when pump is lifted out of wetwell.
3. Pump metal parts that come into contact with guide rail or cable system shall be made of nonsparking materials.

E. Oil chamber between seals shall be equipped with drain and inspection plug. Plug shall have positive antileak seal and shall be easily accessible from outside.

F. Motor nameplate horsepower not to be exceeded at head-capacity point on pump curve.

G. Pump motor and sensor cables shall be suitable for submersible pump application and cable sizing shall conform to NFPA 70 specifications for pump motors. Cables shall be of sufficient length to reach junction boxes without strain or splicing.

H. Motor Protection Module: If required, provide pump with a motor protection module for remote mounting. Contract Drawings are based on first named submersible pump manufacturer and motor protection module. If pump and motor protection module other than first named manufacturer is provided, provide revised wiring for the motor protection module.

I. Cable Entry System:

1. Junction chamber and motor separated by stator lead sealing gland or terminal board that prevents foreign material entering through pump top.
2. Utilize cable with factory-installed sealing gland with nonshrink epoxy seal system.
3. O-ring compression seal between sealing gland and cable entry point shall also be acceptable.

2.04 CONTROL PANEL

A. NEMA 4X enclosure, for outdoor duty.

B. Refer to Section 40 90 11, Instruments and Panels Subsystem (IPS), for additional panel requirements.

C. Free standing, post mounted.

D. Features:

1. Main circuit breaker disconnect interlocked with panel door.
2. Combination circuit breaker type, NEMA rated motor starters.
3. Fused control power transformer, 120V ac.
4. Alternator and pump lead-lag controls.
5. ON/OFF/AUTO switches.
6. Running lights.
7. High level indication.
8. Normally closed, dry, 5 amps at 120V ac contacts for remote indication of:
   a. High level alarm.
   b. Pump failure (temperature or moisture alarm).
9. Terminal strip for interfacing with external wiring.
10. High temperature indication.
11. Moisture alarm indication.
12. Alarm (high temperature, moisture, or high level) beacon located on top of panel.
13. Lightning protection.
14. Intrinsically safe relays as required for UL validation.
15. Alarm silence button.
16. Document pocket located inside panel with pump and panel operation and maintenance manual, and separate laminated pump curve.
17. 110-volt, duplex GFI outlet, weather-protected, and accessible from outside of panel.
18. Run hour meter.
19. 100 watts minimum, condensation heater with thermostat.
20. UL listing mark.

E. Prewired and factory tested.

F. Mount control switches, indicating lights, and switches on hinged front panel.

G. Single Feed: 480 volts, three-phase.

2.05 ACCESSORIES

A. Level Switches: In accordance with Section 40 90 11, Instruments and Panels Subsystem (IPS), component **[A: L8] [B: L29] [C: L30]** and for:

1. Low Low Level: Pumps off.
2. Low Level: First pump on.
3. High Level: Second pump on.

4. High High Level: Alarm.

B. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

D. Sidewalk Door: Size as shown on Drawing or if not shown, sized by equipment manufacturer. As specified in Section 05 50 00, Metal Fabrications, with the following additional requirements:

1. Gasketed and odor tight.
2. Channel drain is not required.

2.06 FACTORY FINISHING

A. Prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Manufacturer's standard epoxy system for continuous submergence in corrosive water.

2.07 SOURCE QUALITY CONTROL

A. Control Panel:

1. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.
2. Factory Tests and Adjustments: Test onecontrol panels identical to that furnished.

B. Pump:

1. Factory Performance Test:
   a. In accordance with HIS 11.6, Level A for submersible pump tests.
   b. Include test data sheets curve test results performance test logs.
2. Conduct on each pump.
3. Perform under actual or approved simulated operating conditions.

C. Submersible Motor Functional Test: In accordance with HIS 11.6.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Mount the discharge elbow to the floor of the wetwell floor with stainless steel bolts.

C. Connect piping without imposing strain to flanges.

D. No portion of pump shall bear directly on floor of sump.

3.02 FIELD FINISHING

A. Equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Test: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation**,** proper alignment and connection, and quiet operation.
2. Flow Output: Measured by plant instrumentation and storage volumes.
3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
4. Test for continuous 3-hour period.
5. Test Report Requirements: In accordance with Hydraulic Institute Standards for submersible pump tests HIS 14.6 and 11.6.

B. Vibration Test:

1. Test with units installed and in normal operation, and discharging to connected piping systems at rates between low discharge head and high discharge head conditions specified, shall not develop vibration exceeding limits specified in HIS 11.6.
2. If units exhibit vibration in excess of limits specified, adjust or modify as necessary. Units that cannot be adjusted or modified to conform as specified shall be replaced.

C. Pump Test:

1. General:
   a. Conduct on each pump provided.
   b. Conduct in accordance with HIS 11.6.

2. Routine Production Tests:
   a. Check impeller, motor rating and electrical connections for compliance to specification.
   b. Test motor and cable insulation for moisture content and insulation defects.
   c. Prior to submergence, run pump dry to establish correct rotation and mechanical integrity.
   d. Conduct abbreviated three-point operational performance test.
   e. After operational performance test, perform insulation test again.
3. Factory Seven-Point Plotted, Performance Test:
   a. Level A for submersible pump tests.
   b. Include test data sheets curve test results performance test logs.
   c. Perform under actual or approved simulated operating conditions.
4. Vibration test.
5. Hydrostatic test.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for inspection.
2. 3 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for prestartup classroom or Site training.
4. 3 person-days for facility startup.
5. 1 person-day for post-startup training of Owner's personnel. Training shall not commence until accepted detailed lesson plan for each training activity has been reviewed by Engineer.

B. See Section 01 43 33, Manufacturers' Field Services Section 01 91 14, Equipment Testing and Facility Startup**.**

3.05 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is part of this Specification.

1. Data Sheets: Pump and Motor.

END OF SECTION

SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04-1

Tag Numbers:

Pump Name: Influent Lift Station Pumps

Manufacturer and Model Number: (1) Xylem (Flygt), CP3306/605 3-831

(2)

SERVICE CONDITIONS

Liquid Pumped (Material and Percent Solids): Raw Sewage

Pumping Temperature (Fahrenheit): Normal: 70 Max 90 Min 60

Specific Gravity at 60 Degrees F: 1.0 Viscosity Range:

pH: 6-10

Abrasive (Y/N) Y Possible Scale Buildup (Y/N): Y

Minimum diameter solid pump can pass (inches) 4

Min. NPSH Available (Ft. Absolute): 42

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 4460 Secondary: 5000

Total Dynamic Head (Ft): Rated: 46.2 Secondary: 40

Min. Rated Pump Hydraulic Efficiency at Rated Capacity (%): 83

Max. Pump Speed at Rated Capacity (rpm): 880 Constant (Y/N): N
Adjustable (Y/N): Y

DESIGN AND MATERIALS

Pump Type: Heavy-Duty Nonclog (Y/N) Y Other:

Volute Material: Cast Iron ASTM A48
Pump Casing Material: Cast Iron ASTM A48

Motor Housing Material: Cast Iron ASTM A48

Wear Rings Case (Y/N): Y_____ Material: Brass_____

Wear Ring Impeller (Y/N): Y_____ Material: Stainless Steel_____

DRIVE MOTOR See Section 16171, Low-Voltage AC Induction Motors

Horsepower: 70____ Voltage: 480____ Phase: 3_____ Synchronous Speed (rpm): 1150__

Enclosure: EXP_____

Adjustable Speed Drive Range: 660 min to 880 max, See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Other Features: _____

Moisture Detection Switches (Y/N): Y_____

Thermal Protection Embedded in Windings (Y/N): Y_____

REMARKS: _____

_____

_____

_____

SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04-2

Tag Numbers: M-451, M-452, M-453

Pump Name: Return Activated Sludge Pump

Manufacturer and Model Number: (1) Flygt, NP 3153

(2) _____

SERVICE CONDITIONS

Liquid Pumped (Material and Percent Solids): Return activated sludge

Pumping Temperature (Fahrenheit): Normal: 70 Max 90 Min 60

Specific Gravity at 60 Degrees F: 1.0 Viscosity Range: _____

pH: 6-10

Abrasive (Y/N) Y Possible Scale Buildup (Y/N): Y

Minimum diameter solid pump can pass (inches) 2

Min. NPSH Available (Ft. Absolute): 42

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 2,470 Secondary: 3,298

Total Dynamic Head (Ft): Rated: 13.8 Secondary: 22.9

Min. Rated Pump Hydraulic Efficiency at Rated Capacity (%): 72

Max. Pump Speed at Rated Capacity (rpm): 1150 Constant (Y/N): N
Adjustable (Y/N): Y

DESIGN AND MATERIALS

Pump Type: Heavy-Duty Nonclog (Y/N) Y Other: _____

Volute Material: Cast Iron ASTM A48
Pump Casing Material: Cast Iron ASTM A48

Motor Housing Material: Cast Iron ASTM A48

Wear Rings Case (Y/N): Y Material: Brass

Wear Ring Impeller (Y/N): Y Material: Stainless Steel

SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04-3

Tag Numbers: M-451; M-452, M-453

Pump Name: Return Activated Sludge Pump

Elastomers: Nitrile Rubber

Fasteners: Stainless Steel

Impeller: Type: Double-Shrouded Non-Clog (Y/N): _____ Other: _____
Material: Cast Iron ASTM A48

Shaft Material: Carbon Steel, ASTM A576 with stainless steel sleeve or all stainless steel.

Base Elbow: Cast Iron ASTM A48

Double Mechanical Seal (Y/N): Y Bearing Life (Hrs): 100,000

SECTION 11307
SUBMERSIBLE CHOPPER PUMP

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

A. Conform to Division 1, General Requirements.

B. Contractor shall furnish submersible wet pit recirculator chopper pump and appurtenances as specified. Pump shall be specifically designed to pump waste solids at heavy consistencies without plugging or dewatering of solids. Materials shall be chopped/macerated and conditioned by pump as an integral part of pumping action. Pumped fluid can either be recirculated within wet well, or discharged, or a combination of recirculation/discharge. Pump must have demonstrated the ability to chop through and pump high concentrations of solids such as plastics, heavy rags, grease and hairballs, wood, paper products and stringy materials without plugging, both in tests and field applications.

C. Provide equipment from the named Supplier as outlined herein.

1.02 INTENT OF SECTION

A. This section covers supply, delivery, Site storage, installation, testing and placement into operation of pumping equipment and includes motors, drives, control equipment, supports, guide rails, and all appurtenances necessary for an operating system.

B. Provide all pumps of similar design from one manufacturer.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete attached pump datasheet.
   b. Hydraulic calculations for the head required by pump.
   c. General layout of each pump unit complete with motor and drive showing anchor bolt locations, casing position, direction of rotation and electric motor terminal box location.
   d. Cross-sectional details of each pump and pump seal with complete cross-referenced materials list.

e. Baseplate, structural steel base, and steel guide rails complete with anchor bolt details.
f. Certified, characteristic curves including head, capacity, efficiency, net positive suction head and power expressed in kilowatts.
g. Details of impeller size, pump RPM, and solid sphere passing capacity.
h. Dimensional drawings of motors and drives, including full output power in kilowatts, rpm, and slip.
i. Seal lubricating water requirements.
j. Details of storage and off loading requirements.
k. Sample warranty.

B. Informational Submittals:

1. Quality Control Submittals:
   a. Performance affidavit.
   b. Certified, nonwitnessed, shop test results for all pumps.
   c. Manufacturer's installation manuals.
   d. List of recommended spare parts with current prices and anticipated delivery times.
   e. Operation and Maintenance Data: As specified in Section 01782, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Provide manufacturer's standard warranty and a performance affidavit for equipment to be furnished in accordance with this specification.

1. Warranty for workmanship and materials shall be manufacturer's standard for 1 year from startup, not to exceed 18 months from factory shipment.
2. Performance Affidavit:
   a. Manufacturer shall certify to Contractor and Owner that Contract Documents have been examined, and that equipment will meet in every way the performance requirements set forth in Contract Documents for application specified.
   b. Engineer will not review Shop Drawings prior to receipt of an acceptable performance affidavit.
   c. Shall be signed by an officer of the company manufacturing the equipment and witnessed by a notary public.
   d. Shall include a statement that equipment will not clog or bind on solids typically found in application set forth.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. General:

1. The following specifications do not purport to cover all details entering into the design of pumping units required, but rather to call attention to certain special features.
2. Provide workmanship, materials, and methods of construction that conform to best practice and highest standard of the industry.
3. Supply and install units complete in all particulars and ready for operation.
4. Design and proportion all parts to have liberal strength, stability, stiffness, and to be specially adapted to the conditions of service.
5. Tailor pump capacities and impeller diameters to actual pump speeds imparted by pump drives. Base pump capacities on motor speed.
6. Provide pumping units that satisfy the performance specified for the service indicated. Pumps may be certified on water, however, pumps will not be accepted until performance specified is demonstrated on the service indicated.

B. Materials, equipment, and accessories specified in this section shall be products of:

1. Vaughan Company, Inc.
2. Approved Equal

2.02 SERVICE CONDITIONS

A. Pump specified in this section will pump scum from secondary clarifiers using the following design flow criteria:

1. Design flow: 200 gpm
2. Total Dynamic Head: To be determined by Supplier.
3. Horsepower: To be determined by Supplier.
4. RPM: To be determined by Supplier.

B. Furnished pumps may have a minimum flow that is higher than design flow specified herein. It must be possible to recirculate all pump flow that exceeds design flow within scum box.

2.03 PUMP CONSTRUCTION

A. Provide solids handling pump especially constructed for pumping scum and other typical solids at wastewater treatment plants.

B. Casing and Back Pull-Out Adapter Plate:

1. Casing: Semi-concentric design, with first half of circumference being cylindrical beginning after the pump outlet, and the remaining circumference spiraling outward to the 150 pound flanged centerline discharge.
2. Back Pull-out Adapter Plate: Shall allow removal of pump components from above casing and allow external adjustment of impeller-to-cutter clearance.
3. Casing and adapter plate shall be ASTM A536 ductile cast iron with all water passages to be smooth, and free of blowholes and imperfections for good flow characteristics.

C. Impeller:

1. Semi-open chopper type.
2. Chopping/maceration of materials must be accomplished by action of the curved, cupped and sharpened leading edges at bottom of impeller blades as they move across cutter bar, creating a smooth efficient slicing effect.
3. Pump-out vanes must be provided across entire diameter of impeller on backing plate in order to reduce pressure in seal area, and to draw lubricant down from reservoir should seal leakage occur.
4. Held in place with a key and shall have no axial adjustments or set screws, and shall not extend past the cutter bar.
5. ASTM A148 cast alloy steel and heat treated to a minimum 60 Rockwell C Hardness, and dynamically balanced.

D. Cutter Bar:

1. Shall be single cast component recessed into pump bowl with a funnel shaped inlet opening.
2. As a part of the casting, segment bars shall extend inwardly, to within 0.38mm (0.015”) of the cutter nut.
3. Set clearance between cutter bar and impeller shall be adjustable to 0.25mm to 0.38mm (0.010” to 0.015”).
4. ASTM A148 cast alloy steel and heat treated to a minimum 60 Rockwell C Hardness.

E. Upper Cutter Assembly:

1. Impeller pump-out vanes shall be specially modified to shear against upper cutter assembly mounted into back side of casing, in order to eliminate build up of rags, hair, or other stringy material in seal area or between impeller and pump casing.
2. Shall consist of no more than 2 cutting anvils to minimize potential for binding.
3. Set clearance between impeller and upper cutter shall be adjustable to 0.254mm (.010”) or less.
4. AISI 8620 alloy steel case hardened to a minimum 60 Rockwell C Hardness.

F. Cutter Nut:

1. Use to affix impeller to shaft and to eliminate binding or wrapping of stringy materials at pump inlet.
2. Shall consist of hex head sufficiently sized for ease of removal, and shall include integral cast anvil which shears against adjacent surface of segment bars on cutter bar.
3. AISI 8620 alloy steel case hardened to a minimum 60 Rockwell C Hardness.

G. Pump Shafting:

1. Pump shaft and impeller shall be supported by ball bearings.
2. AISI 4140 heat treated steel.
3. Minimum diameter of 38 mm (1-1/2 inches) in order to minimize deflection during solids chopping.

H. Bearing Housing:

1. ASTM A536 ductile cast iron and machined with piloted bearing fits for concentricity of all components.
2. Piloted motor mount shall firmly align motor on top of bearing housing.

I. Thrust Bearings:

1. Shaft thrust in both directions shall be taken up by 2 back-to-back mounted single-row angular contact ball bearings.
2. Overhang from centerline of lower thrust bearing to seal faces shall be a maximum of 30.5mm (1.2”).
3. Shall be oil bath lubricated in bearing housing by ISO Grade 46 turbine oil, with a minimum B-10 life rated 100,000 hours.

J. Pump Mechanical Seal:

1. Provide to isolate bearings from pumped media at operating temperatures to 250 degrees F.
2. Shall be fitted with silicon carbide seal faces to provide long life expectancy in the presence of grit and abrasive solids.
3. Seal shall ride on Type 316 stainless steel shaft sleeve with seal tension held by 3 set screws.
4. Seal shall be tested for flatness within 2 Helium light bands under a Helium light source and optical flat.
5. Single-spring rubber bellows-type mechanical seals are unacceptable.

K. Automatic Oil Level Monitor:

1. Mount oil level switch at top of wet well, with hose feeding down to the side of bearing housing to detect oil level and shut off motor in event of low oil level.
2. Include sensitive relay for mounting in motor control panel.

L. Shaft Coupling:

1. Submersible motor shall be close coupled directly to pump shaft using solid sleeve coupling that is keyed to both pump and motor shaft.
2. Slip clutches and shear pins between shaft and motor are unacceptable.

M. Recirculation Nozzle Assembly:

1. Fit pump with recirculation nozzle assembly to permit recirculation of wet well contents prior to and during discharge.
2. Shall be adjustable minimum 180 degrees horizontally and 70 degrees vertically.
3. Connect valve assembly to pump discharge to adjust pump flow either to recirculation nozzle or pump discharge flange. Valve shall be ASTM A536 ductile cast iron construction with Type 316 stainless steel valve disk.
4. Operating levers shall be located above at a mounting plate accessible from the walkway above wet well.

N. Stainless Steel Nameplates: Attach to pump and drive motor giving manufacturer's model and serial number, rated capacity, head, speed and all pertinent data.

2.04 GUIDE RAILS

A. Provide guide rail system for each pump consisting of 2 stainless steel guide rails, cast ductile iron pump guide bracket, and discharge elbow with mounting feet and 150 pound ANSI flange, an upper guide rail mounting bracket, and intermediate guide brackets spaced at a maximum interval of 3 meters.

B. Provide lift chains suitable for lifting pumps from wet well along guide rails.

2.05 SUBMERSIBLE ELECTRIC MOTOR

A. Provide submersible motor in accordance with Division 16.

B. Submersible motor shall include the following:

1. CSA approved and suitable for Class I, Zone 1, Group IIA locations.
2. Suitable for connection to 480 Volt, 60 Hertz, and 3-phase power supply.
3. Class B insulation system with Class F materials.
4. Tandem mechanical seals in oil bath and dual moisture sensing probes. Lower motor seal shall be exposed only to lubricant in bearing housing, with no exposure to pumped fluid.
5. Two normally closed automatic resetting thermostats connected in series and imbedded in adjoining phases.
6. Frame shall be cast iron, and hardware and shaft shall be stainless steel.

2.06 SURFACE PREPARATION AND PAINTING

A. All wetted parts shall be SSPC-SP5 white metal sandblast.

B. Finish coat all surfaces with a total of 4 mil minimum dry film thickness of stainless steel pigment epoxy top coat, or approved equivalent.

2.07 CONTROL PANEL

A. Pump shall be controlled from a local NEMA 4X control panel.

B. Control panel shall include the following:

1. Hand/Off/Auto handswitch for each pump, pump running lights, low oil level alarm lights, moisture alarm lights, overload alarm lights, and Equalization tank high and low level alarm lights.
2. Logic controller that turns pump on and off based on liquid level.

3. Equalization Tank Transmitter:
   a. Locate in control panel.
   b. Mount so level display is visible with the panel door closed.
   c. Pushbuttons on face of transmitter shall be accessible with control panel door closed.
4. Provide discrete alarm relay for each pump to indicate fault condition (low oil level, overload, and moisture).
5. Provide discrete alarm relay for high high water level. This relay shall be connected to Package Wastewater Treatment Plant control panel.
6. Provide discrete alarm relay for low low water level. This relay shall be connected to Package Wastewater Treatment Plant control panel.

PART 3 EXECUTION

3.01 FIELD TESTING

A. Field test pump in presence of Engineer or Owner's representative to demonstrate that installation is correctly completed and each pump is operating satisfactorily without vibration or cavitation.

B. Field test shall be supervised by pump manufacturer's representative.

C. Engineer requires 72 working hours written notice prior to such tests.

D. Field test pump with water prior to or during testing of process equipment. Perform second field test on specified service fluid during initial process startup.

E. Supply required metering devices and gauges necessary to demonstrate pump performance. Supply and install gauge connections as required.

F. Test results must be properly documented and presented to Engineer.

G. Successful field tests done on water shall not constitute acceptance of pumping unit. Pump will be accepted only after successful performance tests on specified service.

END OF SECTION

SECTION 11331
MECHANICALLY CLEANED FINE BAR SCREENS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes the furnishing of a front-cleaning, front-return link driven mechanically cleaned bar screen assembly and any auxiliary equipment or accessories to be installed in the location as indicated on the drawings and as specified herein.

1. Number of units: 1.
2. Equipment designation: [ ].
3. Equipment location: Headworks Building.

B. All equipment supplied under this section shall be furnished by or through a single Screening System Supplier who shall coordinate with the Contractor, the design, fabrication, delivery, installation and testing of the screening components. The Screening System Supplier shall have the sole responsibility for the coordination and performance of all components of the screenings system with the performance and design criteria specified herein.

C. The Contractor shall be responsible to coordinate all details of the screening equipment with other related parts of the Work, including verification that all structures, piping, wiring, and equipment components are compatible. The Contractor shall be responsible for all structural and other alterations in the Work required to accommodate the equipment differing in dimensions or other characteristics from that contemplated in the Contract Drawings or Specifications.

1.02 RELATED SECTIONS

A. The following list of related sections is provided for the convenience of the Contractor and is for reference only to support commonly referenced sections that are in-general applicable to all equipment supplied. (For complete list of sections see specification index).

1. All sections of Division 1 including but not limited to Submittal Procedures, Shop Drawings, Product Data and Samples, Operating and maintenance information, Protection of Materials and Equipment, Installation, Testing, and Commissioning, Instruction of Operations and Maintenance Personnel, and Spare Parts Maintenance Manuals.
2. Section [ ]-Anchorage.
3. Section [ ]-Coating Systems.

4. Section [ ]-General Requirements for Equipment.
5. Section [ ]-Electric Motors.
6. Section [ ]-Control Panels.

1.03 REFERENCE STANDARDS

A. American National Standards Institute (ANSI).

B. American Society for Testing and Materials (ASTM).

C. American Welding Society (AWS).

D. American Institute of Steel Construction (AISC).

E. American Bearing Manufacturers Association (ABMA).

F. American Gear Manufacturers Association (AGMA).

G. National Electrical Manufacturers Association (NEMA).

H. Underwriters Laboratory (UL).

1.04 SUBMITTALS

A. The equipment manufacturer shall submit the following items:

1. 6 sets of General Arrangement drawings that illustrate the layout of the equipment, equipment weight, principal dimensions with related verifications required for installation including anchorage locations. Other related data including descriptive literature, Electrical Control Drawings, Catalog Cut Sheets for individual components and Drive Motor Data.
2. A list of recommended Spare Parts including any Special Tools required for routine maintenance of the equipment is provided in Section 2.5.
3. 6 sets of O & M Manuals including As-Built Drawings of the Mechanically Cleaned Bar Screen Arrangement, Controls and Accessories shall be provided in digital format after equipment ship for inclusion in the Close-Out Submittal process.
4. For sites that have 3 feet or greater head differential, equipment manufacturer shall provide Structural Certification from licensed Civil engineer.

1.05 QUALITY ASSURANCE

A. The Mechanically Cleaned Bar Screens shall be fully assembled and shop tested at the manufacturing facility prior to shipment. Shop testing shall include a minimum of 4 hours of run time.

B. To assure quality and performance: All equipment furnished under this Section and related sections shall be of a single manufacturer who has been regularly engaged in the design and manufacture of the equipment and demonstrates, to the satisfaction of the Engineer, that the quality is equal to equipment made by those manufacturers specifically named herein. And the screen manufacturer shall have at least 25 installations of the specified model of mechanically cleaned bar screen equipment that has been in successful operation, at similar installations, for at least five 5 years.

C. The equipment furnished shall be fabricated, assembled, installed and placed in proper operation condition in full conformity with approved drawings, specifications, engineering data, and/or recommendations furnished by the equipment manufacturer.

1.06 WARRANTY

A. Manufacturer shall provide a written one year standard warranty from the date of use of the mechanically cleaned bar screen equipment to guarantee that there shall be no defects in material or workmanship in any item supplied.

B. Manufacturer shall warrant for the period of 5 years all rotating parts of the Mechanically Cleaned Bar Screen including the gear motor, bearing, drive head, and the link system including the links, castings, pins and retaining rings. Manufacturer warrants that these components shall be replaced if damaged or defective in the normal use of the equipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Screen [s] shall be as manufactured by Duperon Corporation, 1200 Leon Scott Court, Saginaw, Michigan, TF 800.383.8479. The screens shall be the FlexRake® Model, Full Penetration Fine Screens.

B. Or approved equal. If Contractor uses an approved equal manufacturer, Contractor shall assume costs associated with changing the design for said manufacturer.

2.02 BASIS OF DESIGN

A. The mechanically cleaned bar screen shall have a head sprocket only, with no sprockets, bearings, idlers, or similar drive components under water to trap the chain. Equipment featuring reciprocating rake arms or lower bearings/sprockets/tracks below the water is not acceptable.

B. The mechanically cleaned bar screen shall meet the total screen debris removal capacity of:

1. Scraper Ratio below Water Level:

a. Upstream Water Level (ft) = Number of Scrapers below Water level 1.745 ft.
b. Debris Volume per Linear Foot = 0.152 ft^3 /hr (0.046 m^3/m).
c. Total Screen Debris Removal Capacity on Low (ft^3/hr) = (0.152 ft^3/ft) x (Screen Width) x 60 x (Number of Scrapers below Water Level).
d. Total Screen Debris Removal Capacity on High (ft^3/hr) = (0.152 ft^3/ft) x (Screen Width) x 260 x (Number of Scrapers below Water Level).

C. The flow ability of the screen area, specifically, shall be defined as follows: A composite number representing the specific flow- ability of a screen area composed of the bars' Hydraulic Headloss.

1. Coefficient Shape Factor, the bar width and the clear opening of the screen field per formula below.

$$\text{(Coefficient Shape Factor)} \times \left(\frac{\text{Bar Width}}{\text{(Clear Opening)}}\right) = \left(\frac{0.190}{\text{(Clear Opening)}}\right)$$

D. The mechanically cleaned bar screen shall be designed to run continuously (24/7), without operator.

E. The equipment shall have multiple scrapers on the bar screen at one time cleaning continuously from bottom to top, the entire width of the bar screen. The drive output shaft rotation shall be constant and in one direction in order to reduce maintenance and increase product life. Units which have single raking arms or that require cycle times shall not be allowed. Cleaning mechanisms that utilize shock absorbers, springs or other dampening or hydraulic actuations are unacceptable.

F. The link system shall have jam evasion capability by flexing around and collecting large objects such as a 2 by 4, bowling ball, grease balls and surges of solids at peak loading times without overloading and shutting down the unit. The link system shall be such that it bends in one direction only which allows it to become its own lower sprocket and frame and shall have a 1,000 pound lifting capacity.

G. Designs employing the use of endless moving media or cables and hydraulic cylinders to remove debris from the channel and units utilizing proximity or limit switches for reverse cycles are not acceptable.

H. Equipment utilizing a greater than 1/2 hp motor or two or more motors to complete a screen cleaning cycle is not acceptable.

I. The design shall be such to ensure that all maintenance can be accomplished at the operating floor level or above. No part of the drive system including sprockets shall be located below the water surface at maximum design flow.

J. Design Conditions:

Site Installation Information:	
Channel Width:	4.0 ft
Channel Height:	7.6 ft
(upstream clearance) Channel Depth:	7.6 ft
Bar Opening Size:	1/4"
Angle of Installation:	70 degrees
Average Flow:	
Average Water Level:	
Maximum Flow:	19.2 mgd
Maximum Water Level:	5.5 ft
Maximum Head Differential:	3 ft
Equipment Location:	Indoors
Indoor Installation:	
Ceiling Clearance Height:	

Site Installation Information:	
Site Access Constraints:	
Roof Opening Available:	No
Door Opening Size:	
Other Site Constraints:	
Installation Area Classification:	Class I Div I
Collection and Conveyance	
Containment Height:	Match Existing
Debris Bin:	Dumpster
Conveyor:	Existing
Washer/Compactor:	No
Other:	

2.03 COMPONENTS

A. Bar screen assembly: Bar screen assembly shall be of stainless steel and designed to withstand 1 foot head differential unless noted otherwise in Section 2.2 J Design Conditions. Unless noted otherwise materials of construction shall be 304 Stainless Steel. A stainless steel channel bottom plate shall be an integral part of the bar screen assembly to fully engage scrapers in the bar screen at the base of the unit and assure that the raking mechanism reaches the bottom of the screen to prevent debris accumulation. The Bar screen assembly shall be shipped in one piece.

1. Screen Bars: Bars shall be Type 316L stainless steel and be tear-shaped with a Hydraulic Coefficient shape factor of 0.76 and the minimum dimensions of 0.25 inch by 0.75 inch by 0.13 inch. Bars shall be individually replaceable without welding.
2. Side Fabrication: The screen framework shall be Type 304 stainless steel bent plate with minimum of 3/16 inch cross section. Horizontal members shall be of stainless steel bent plate or stainless steel pipe. Support members and frame shall adequately support the bar screen based on site specific requirements.
3. Dead Plate: Dead plate shall be 0.25 inch thick Type 304 stainless steel. The dead plate shall be flat and true; span the entire width of the unit; and transition from bar screen to discharge point.

4. Discharge Chute: The discharge chute shall be 11ga. (0.12 inch) Type 304 stainless steel. The discharge chute shall be bolted to the dead plate and shall be designed to allow debris to be transferred from discharge point into the debris containment.
5. Link Slides: Link slide assembly shall be provided per manufacturer standard design and shall be constructed of UV Stable UHMW PE rollers and Type 304 stainless steel supports and components.

B. Return Guide/Closeouts: Return guide/Closeouts shall be Type 304 stainless steel and shall assure proper alignment of scrapers as they enter the bar screen and assure that there is no space wider than the clear opening between bars to prevent passage of larger solids than allowed through the screen.

C. Debris Blade: A 304 stainless steel and UV Stable UHMW-PE debris blade assembly, which does not require a separate drive, shall be installed to assist in removing debris from the scraper on the mechanically cleaned bar screen unit as recommended by the manufacturer.

D. Screen Enclosure: A 14ga. #4 brushed satin finish 304L stainless steel Enclosure shall be installed to cover the screen above the operating deck level. Front Enclosure shall have removable panels for access to equipment. Removable panels shall be 16ga. Type 304L stainless steel and shall be provided with knurled knobs for "no tool required" access. Alignment notches shall be included to support repositioning of removable panels. The top of the Front enclosure shall include a knock out for a customer site option to install a 6-inch diameter pipe stub. (The option of connecting to the site's exhaust system, to provide a positive air exchange from interior of enclosure, by Others.) Rear Enclosure shall have hinged removable doors and shall be secured with a lift-slide-latch handle. Rear removable door shall include an integral viewing door that shall be secured with a lift-slide-latch handle to provide access for a quick look inside.

1. Front Enclosure Design Options: stainless steel removable panels.

E. Link System: The link system shall be stainless steel castings and have a minimum ultimate strength of 60,000 pounds with a minimum cross section of 1.5 inches and weighing a minimum of 4.5 pounds each.

1. Type 316 stainless steel link system includes Type 316 stainless steel retaining rings and Type 316 stainless steel pins.

F. Scrapers: Scrapers shall be spaced 21 inches apart. To provide long product life the scraper shall move at no greater than 28 inches per minute at standard operating speed of 1/2 rpm allowing for approximately 1 debris discharge per minute. Staging Scrapers and Thru Bar Scrapers shall be a maximum ratio of 3:1 per manufacturer recommendations. At least one scraper every 84 inches shall fully penetrate the bar screen, cleaning all three sides of the bars as well as through to the cross members in openings of 0.25, 0.375 and 0.50 inches.

1. Staging Scrapers; Staging Scrapers shall be 1 inch thick x 4 inches x screen width UV Stable UHMW-PE with a serrated edge.
2. Thru Bar Scrapers: Thru Bar Scrapers shall be minimum .375 inch thick by 5 inches x screen width 304 stainless steel.

G. Drive Head: The Drive Head shall be located at the top of the mechanically cleaned bar screen.

1. Drive Unit: Each mechanically cleaned bar screen unit shall operate independently and shall have its own drive unit and driven components.

   a. Drive Sprockets and end castings shall be cast 304 stainless steel.
   b. Drive Shaft shall be 304 stainless steel.
   c. Gearbox shall be shaft-mounted, right angle type and include spiral bevel gearing. The output shaft speed shall be controlled by a vector type inverter or per rake manufacturer's recommendation. It shall have at least a 1.52 or greater service factor based on machine torque requirements. The gearbox shall not be vented to the outside atmosphere. The gearbox shall be grease filled. Oil filled gearboxes are not allowed.
   d. The motor shall be AC induction type, inverter duty, 3 phase, 240/480 volt and mounted to the gear reducer. The motor shall be 1/2 hp, designed for 1800 RPMs base speed and rated for Class I, Groups C & D, Class II Groups F & G environments. The motor shall have an EPNV enclosure, NEMA design B with a 56C frame size. Service factor shall be 1.0 or greater, Class F insulation and be optimized for IGBT type inverters. The motor must be UL listed and designed for continuous operation.
   e. Motor shall have built in, normally closed, thermostat to protect from overheating that is to be field wired to corresponding terminal in control panel for redundant (ambient) overload protection.
   f. All drive head components shall be of components available in the United States.

2. Bearing: Bearing shall be greased ball bearing type, non self-aligning, sealed and lubricated and shall have a 24/7/365 L10 life of 20 years when in compliance with stated O&M recommendations.
3. Speed Reducer: Speed reducer shall be a double-reduction, cycloidal style and shall comply with all applicable AGMA standards. The speed reducer shall be capable of a 4/1 speed range with variable output speeds between 0.50 to 2.2 output RPMs (in high flow conditions). The speed reducer shall produce an output torque of 11,417 in.lb. and have a gear ratio of 809:1.

H. Coating: All non-stainless bar screen components shall be coated in strict accordance with the paint manufacturer's specification. Surface Preparation shall be done in accordance with SSPC-SP-10 Near White. The three-part coating system shall be manufactured by Tnemec as follows: Prime Coat Series 90-97 Tneme Zinc at 2.5-3.5 mils DFT, Intermediate Coat Series 27 F.C. Typoxy at 3.0-5.0 mils DFT, and Top Coat Series 1075U Endura-Shield II at 2.0-3.0 mils DFT. Standard color is 11SF Safety Blue. Material shall meet all state and federal VOC and other regulatory requirements.

2.04 ELECTRICAL, CONTROLS, INSTRUMENTATION

A. General: Controls for each rake shall be in enclosures provided by the bar screen manufacturer. The bar screen manufacturer shall be responsible for proper sizing and function of the controls at 480V, unless specified otherwise.

1. Main control panels require shading from the sun and shall be operated within a temperature range between 35 degrees F and 104 degrees F. Sunshields, visors or other structures needed to provide shade are by others. (If the controls will experience temperatures outside this range, then special climate provisions are available.)
2. Controls shall be designed to accept incoming power supply per plans/specs and shall include a step-down transformer as needed to achieve 120V.
3. Control Panel(s) shall be constructed to meet the appropriate NEMA classification requirements and will include a main, lockable disconnect. The panel will be constructed by a UL certified control panel build facility and will be supported by the appropriate UL labeling.

4. Controls shall be tested prior to shipment to owner. The rake manufacturer shall verify all overload settings in the rake controller to insure proper overload and speed settings required for the application are properly programmed.
5. Control panel(s) shall be wired complete with a minimum of #16 MTW wire in the appropriate colors for the circuits being supplied. 120V ac control shall be red, grounded AC neutral shall be white, DC control shall be blue, DC neutral shall be blue with a white tracer, equipment ground shall be green and all incoming and outgoing external power source wires shall be a yellow configuration. All ac power wiring shall be a minimum of #12 Black. All wires shall be labeled at both ends with heat-shrink wire markers. Internal panel wiring shall be contained in non-flammable, covered wire way.
6. All panel(s) and panel mounted devices shall be labeled with engraved I.D. markers that reference back to the system schematics. Tags shall be white with black core, engraved as required.
7. All field wiring and power cables between the bar screen Main Control Panel and the Local Push Button Station shall be provided by others under the Electrical Section. VFD rated motor cable (Belden #29502 or equal) is recommended for all motors. Motor cables shall be less than 80 feet unless otherwise specified.

B. Components:

1. Main Control Panel:

   a. Enclosure(s) shall be NEMA 4X Type 304L stainless steel.
   b. Enclosure shall not be located in an explosive environment.
   c. Main Control Panel shall be designed with a SCCR rating of 18KA at 480V ac minimum and labeled as such, unless otherwise specified.
   d. All terminals utilized in the main panel shall be 600V rated terminals and 20 percent spare terminal space shall be provided for any potential future revisions.
   e. The Main Control Panel shall include at a minimum the following
      1) Main fusible disconnect with lockable operator, unless otherwise specified.
      2) Physical or virtual Hand/Off/Auto (HOA) Selector and Push/pull E-Stop button.
      3) Elapsed run-time meter.
      4) Indication for "Power On", "Forward" and necessary faults.

f. Relay Based Controls shall included the following:
   1) Variable Frequency Drive (VFD).
   2) Electronic torque control.
   3) Hard contact SCADA Interlock(s).
   4) Adjustable on/off cycle timers.

g. PLC Based Controls shall included the following:
   1) Programmable Logic Controller (PLC).
   2) Variable Frequency Drive (VFD).
   3) HMI programmable functions as required
   4) SCADA Interlocking via Hard Contact and/or Ethernet Communications Protocols as required.

2. Local Control Push Button Station:
   a. Enclosure shall be NEMA 7/9 rated for Classified area installation. Local push button station must be local to the equipment to maintain requirements of local safety codes as determined by the Engineer.
   b. Local station shall be mounted within 10 feet or as close to the equipment as safely possible and be field wired by the electrical subcontractor to the corresponding terminal inputs in the main control panel.
   c. The remote pushbutton station shall include Forward, Jog Reverse and E-Stop buttons.

3. Instrumentation: Each rake shall have a separate level system that shall be installed and field wired by others per the manufacturer's instructions.
   a. Single Level/Speed Control: When the float trips, the rake runs. When the float returns to the normal position, an off-delay timer is initiated to prevent intermittent equipment starting/stopping.
      1) Mechanical float switch including 50 feet long cabling.
   b. Dual Level/Speed Control: When the low float trips, the rake runs. When the float returns to the normal position an off-delay timer is initiated to prevent intermittent equipment starting/stopping. When the high float trips, the rake runs at high speed until it returns to the normal position.
      1) 2 mechanical float switches, each including 50 feet long cabling.

c. Differential Level Control: Shall use a Unitronics PLC with a built-in HMI. Program shall include multiple differential setpoints used for automatic speed ramping/reducing as the differential level increases/decreases. The uppermost setpoint shall run the rake at high speed. The logic shall also include a "Rake Off" setpoint which shall be lower than the initial run setpoint. This setpoint is required to help avoid intermittent starting/stopping caused by the differential level equalizing with minimal rake run time. Cycle timing logic shall also be included in the program that shall function in parallel with the differential level control logic for optimal rake run time. Level sensing instrumentation shall be installed upstream and downstream from the rake and shall be one of the following types:

1) 2 Siemens Sitran Probe LU Ultrasonic Level Transducers with (1) intrinsically safe hand-held programmer rated for 20 foot range and for Class I Div I hazardous environments. Transducers shall be installed at least 1 foot above the anticipated water elevation and the beam angle shall not have obstructions between the transducer face and the water surface.

C. Controls Design Conditions:

Incoming Power: (Voltage/Phase)	240/480
Enclosures:	Separate
Installation location:	Indoors
Approx. distance between main panel and equipment motor	30 ft
Climate controlled location:	No
Transducer/Float cable length (50 ft standard):	Provide

2.05 SPECIALTY TOOLS, SPARE PARTS AND LUBRICATION

A. Manufacturer shall provide any specialty tools and recommend spare parts required for maintaining the equipment as follows:

1. Drive Clevis Pin: 1.
2. Snap/Retaining Rings: 10.
3. Link Clevis Pins: 4.
4. Scraper Bolts: 4.

5. Scraper Nuts: 4.
6. Snap Ring Tool: 1.
7. Never Seez, 3 oz. tube: 1.

B. Manufacturer shall provide a 5-year supply of lubrication required for maintaining all bar screen components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed in strict conformance with the manufacturer's installation instructions, as submitted with Shop Drawings, Operation and Maintenance Manuals and/or any pre-installation checklists. Installation shall utilize standard torque values and be installed secure in position and neat in appearance. Installation shall include any site preparation tasks as required by the engineer or manufacturer; such as unloading, touch-up painting, etc. and any other installation tasks and materials such as wiring, conduit, controls stands as determined by the customer and/or specified by the manufacturer.

B. Anchor Bolts: Anchor bolts and nuts shall be Type 316 stainless steel and furnished for each item of equipment by the Contractor.

1. Anchor bolt template drawings shall be included in the submittal to permit verification of the location structural elements, new or existing in the concrete.

C. Anchor bolt sizes, quantity and requirements will be indicated on the submittal drawings. Quantity is site specific but typically each Barscreen assembly requires 8 to 12-1/2 inch dia.by 4-1/2 inches Lg. embed HILTI HAS RODS w/ RE-500 SD Adhesive system anchor bolts for Mechanical Screen anchorage and typically 8 to 12 3/8 inch dia. by 3-3/8 inch Lg. embed HILTI HAS RODS w/ RE-500 adhesive system anchor bolts for the Return Guide/Closeouts anchorage.

END OF SECTION

SECTION 13120

PRE-CAST SEGMENTAL CONCRETE BUILDING

PART 1 GENERAL

1.01 SUMMARY

A. Contractor to furnish pre-cast, post-tensioned concrete building. Building to be field erected on a cast-in-place concrete foundation in accordance with manufacturer's recommendations. Pre-cast building to be EASI-SET brand as manufactured by Lonestar Prestress Mfg., Inc., Houston, Texas or approved equal. Building to be provided by manufacturer with all necessary openings as specified in conformance with manufacturer's structural requirements.

1.02 PAYMENT

A. Unless indicated in the Unit Price Schedule as a pay item, no separate payment will be made for work performed under this Section. Include cost of work performed under this Section in pay items for which this work is a component.

1.03 RELATED WORK

A. Division 16 – Electrical: Pre-cast building shall comply with all requirements of Division 16 for conduit, wiring, labeling, devices, and grounding.

1.04 CODES, STANDARDS, AND REFERENCES

A. ACI-318-02, "Building Code Requirements for Structural Concrete".

B. ASCE-7-02, " Minimum Design Loads for Buildings and Other Structures".

C. 2003 IBC, "2003 International Building Code".

D. PCI Design Handbook, Precast/Prestressed Concrete Institute.

E. UL 752, Standard for Safety for Bullet Resisting Equipment, Underwriters Laboratories Inc.

F. "Manual of Standard Practice", Concrete Reinforcing Institute.

G. ASTM, American Society for Testing and Materials:

1. C150 - Standard Spec. for Type I and Type II – Low Alkali Portland Cement.

2. C33 - Standard Spec. for Concrete Aggregates.

3. A36 - Standard Spec. for Carbon Structural Steel.

4. A615 - Standard Spec. for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

5. A706 - Standard Spec. for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.

6. A416 - Standard Spec. for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.

7. A185 - Standard Spec. for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.

8. A307 - Standard Spec. for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

9. A123 - Standard Spec. for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

10. A153 - Standard Spec. for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

1.05 QUALITY ASSURANCE

A. Building fabricator must have a minimum of 5 years experience manufacturing pre-cast, post-tensioned concrete buildings.

B. No alternate building designs to the pre-engineered EASI-SET building will be allowed unless pre- approved by the owner TEN (10) days prior to the bid date.

1.06 DESIGN REQUIREMENTS

A. Dimensions:

1. WCID 111 Lift Station New Electrical Building:

Exterior: 50’-0”x 20''-0” x 12’-10”H

B. Standard Design Loads:

1. Standard Wind Loading - 140 MPH (ASCE 7-02, Category II, Exposure C, Enclosed Building)

2. Standard Roof Live Load - 60 PSF

3. Standard Floor Live Load - 250 PSF

4. Seismic Design category ‘D’, Seismic use Group I

C. Roof: Roof panel shall slope 6” in 10’-0” in the direction of the narrow dimension from peak to edge. The roof shall extend a minimum of 4" beyond the wall panel on each side and have a turndown design which extends 3/4" below the top edge of the wall panels to prevent water migration into the building along top of wall panels. Roof shall also have a straight smooth edge.

D. Keyway Roof Joints: Grout in keyway shall be polymer concrete placed after coating keyway with a methyl methacrylate resin and isocyanate resin.

E. Floor: There shall be a 1/2” deep recess, the width of the wall panels, cast into the floor. The 1/2” recess makes the interior floor surface 1/2” higher than the joint between the wall panel and floor slab preventing intrusion of water.

F. Wall panels shall set on top of floor slab. Wall panels are to be a minimum of 6.5” thick.

G. Walls to be of an insulated precast concrete sandwich panel type. The walls shall have an extruded polystyrene core sandwiched between interior and exterior concrete wythes. The wall panels shall have a minimum thickness of 6.5”. Minimum wythe thickness shall be 2”. The walls shall have a minimum equivalent wood framed wall R-value of R-26 per the 2003 International Energy Conservation Code.

1.07 SUBMITTALS

A. Make submittals in accordance with Section 01330 - Submittal Procedures, and Section 01340 - Shop Drawings, Product Data, and Samples.

B. The submittal shall contain building engineering calculations that are to be designed and sealed by a Professional Engineer licensed in the state of Texas.

C. Summary of design criteria used in the building design including, as a minimum, material properties, loading, and dimensions assumed.

D. Shop drawings containing as a minimum of the following information:

1. Elevations of all four sides of the building as well as plans for the roof and floor. The drawings shall contain critical dimensions required to fully describe the structure as well as allow for accurate field erection. Drawings shall be to scale providing a proportionally accurate representation of the structure.

2. Plan and section drawings showing interior pre-cast concrete partitions (if required).

3. Connection details and pertinent dimensions.

4. Proposed 28-day concrete compressive strength.

E. Product data information sheets including but not limited to:

1. Doors, Door frames, and door hardware including handles/doorknobs, hinges, locks, overhead stops and holders, thresholds and closer, etc. All door finish hardware shall be in compliance with ADA requirements.

2. Interior finish items: fiber reinforced plastic and accessories, base, floor tile, etc.

F. Samples: Samples showing color and texture of the following materials shall be submitted for: fiber reinforced plastic, base material, floor tile, epoxy coating.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete:

1. Concrete shall have 6,000-psi minimum, 28-day compressive strength.

2. Cement used in the manufacture of concrete shall be Low Alkali Type I/II Portland Cement conforming to the requirements of ASTM C150 with total alkalis not to exceed 0.6%.

3. Coarse aggregate shall be crushed limestone with a maximum size per ASTM C33 of 3/4".

B. Reinforcing Steel shall be in accordance with requirements of ASTM A615, grade 60 for deformed bars and ASTM 185, grade 80 for welded wire fabric unless otherwise indicated.

C. Post-tensioning Strandshall be ½" diameter, grade 270, 7-wire, low relaxation strand:

1. Plain
2. Encased in greased plastic sheathing (ASTM A416).

3. If post-tensioning is *not* used in the roof panel, the following guidelines must be followed to ensure a watertight roof design.

a. The entire pre-cast concrete roof panel surface must be cleaned and primed with a material that prepares the concrete surface for proper adherence to the coating material.

b. The entire pre-cast concrete roof panel surface shall be sealed with a .045” EPDM continuous membrane cemented to the concrete with a compound designed for this purpose.

D. Lifting Hardware: The lifting hardware to shall be permanently cast into the concrete and shall be hot dipped galvanized.

E. Caulking: All joints between panels shall be caulked on the exterior and interior surface of the joints. Caulking shall be SIKAFLEX-IA elastic sealant or equal. Exterior caulk joint to be 3/8" x 3/8" square so that sides of joint are parallel for correct caulk adhesion. Back of joint to be taped with bond breaking tape to ensure adhesion of caulk to parallel sides of joint and not the back.

F. Panel Connections: All panels shall be securely bolted together with 3/8” thick steel brackets. Steel is to be of structural quality, hot-rolled carbon complying with ASTM A36 and hot dipped galvanized after fabrication. All fasteners to be 1/2" diameter bolts complying with ASTM A307 for low-carbon steel bolts. Cast-in anchors used for panel connections to be Dayton-Superior #F-63, or equal. All inserts for corner connections must be secured directly to form before casting panels. Floating of connection inserts will not be allowed.

2.02 ACCESSORIES

A. Door and Frame: Shall comply with Steel Door Institute "Recommended Specifications for Standard Steel Doors and Frames” (SDI-l00), and as herein specified. The building shall be equipped with (1) single 4'-0" x 8'-0" x 1-3/4" and one (1) set of double 4’-0”x 9’-0”, 18-gauge steel doors, with insulated core and galvanized. Doors shall open as noted on drawings. Frames shall be 16-gauge

galvanized steel. Doors and frames shall be painted with one coat of rust inhibitor primer and one finish coat of epoxy paint, medium gray, if no other color is specified.

B. Door Hardware:

1. Handle: Lindstrum lever type pull-handle, stainless steel, 8-1/2" x 2".

2. Lockset: City of Houston standard unit.

3. Deadbolt: City of Houston standard unit.

4. Hinges: Hagar stainless steel five knuckle ball bearing with non-removable pins or equal.

5. Threshold: Hagar or National Guard Products extruded aluminum with neoprene seal or equal.

6. Overhead Door Holder: Yale surface mounted overhead slide type with safety release or equal.

7. Drip Cap: Hager or National Guard Products aluminum with stainless steel screws or equal.

8. Door Closer: Norton 7500 or Yale 4410 with hold open or equal.

9. Surface Bolts (Upper and Lower): Magnokrom Inc. 400-401 cadmium plated finish or equal, as required for double doors.

10. Astragal: Galvanized steel, same finish and brand as door, as required for double doors. Astragal shall be removable for equipment access.

11. Door Stop: Ives 445B26D brushed chrome (inactive leaf only) or equal, as required for double doors.

12. PANIC BARS: All doors shall be equipped with panic bars which open doors when pressure is applied to a horizontal bar on the inside of each door.

B. Air Conditioning/Heat Pump Unit: Two-ton wall mount HVAC Unit (BARD or equal) including supply and return air grills.

C. Electrical: The electrical work and materials shall conform to Division 16.

2.04 FINISHES

A. Building Exterior

1. Exposed Aggregate: The exterior finish of the building shall consist of washed brown firestone aggregate on all exterior wall surfaces with the exception of a 4" wide vertical smooth concrete reveal at the building corners. Aggregate must be seeded into top of panel while in form, chemically retarded, and high-pressure water washed to expose the aggregate to a depth of 1/8".

B. Interior of Building: Smooth steel form finish on all interior panel surfaces.

1. The building floor shall be treated with a Sealer/Dustproofer per the manufacturer's recommendations.

2. The walls and ceiling inside the building shall be painted with a minimum of two coats of white paint.

3. Electrical: The electrical work and materials shall conform to Division 16.

PART 3 EXECUTION

3.01 SITE PREPARATION REQUIREMENTS (Cast-In-Place Foundation)

A. The precast, post-tensioned concrete building shall be erected on a cast-in-place concrete foundation. The foundation shall be constructed in accordance with the Contract Drawings.

B. The floor shall have a 1 1/2" x 10" deep recess, the width of the wall plus 3 1/2" wide cast into the floor around the perimeter except at doors. The 1 1/2" recess makes the interior floor surface 1 1/2" higher than the joint between the wall panel and the foundation preventing intrusion of water.

C. The finished floor slab elevation shall be above the exterior grade. The grade shall have a slope such that all drainage will be away from the building at all points.

D. The slab shall be steel reinforced and be level within 1/8" in both directions.

E. Footer depth and reinforcement to be in accordance with Contract Drawings.

3.02 ACCESS

A. Access to the building sites is indicated on the Contract Drawings.

3.03 ERECTION

A. The building manufacturer shall erect the building walls and roof.

3.04 AIR CONDITIONING / HEAT PUMP UNITS

A. The building manufacturer shall install and commission the air conditioning / heat pump units.

END OF SECTION

SECTION 13121
PREFABRICATED BUILDINGS

PART 1 GENERAL

1.01 MEASUREMENT AND PAYMENT

A. Payment for the installation of prefabricated buildings is on a lump sum basis under the pertinent item number.

1.02 REFERENCES

A. ACI 301 - Structural Concrete for Buildings.

B. ACI 318 – Building Code Requirements for Structural Concrete.

C. ASCE 7-10 – Minimum Design Loads for Buildings and Other Structures.

D. ASHRAE 90.1 – Energy Efficient Design of New Buildings, Fundamentals Handbook.

E. ASTM A497 - Welded Deformed Steel Wire Fabric for Concrete Reinforcement.

F. ASTM A615 – Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

G. ASTM C150 – Standard Specification for Portland Cement.

H. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.

I. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials.

J. ASTM E774 – Standard Specification for the Classification of the Durability of Sealed Insulating Glass Units.

K. IBC - International Building Code 2012.

L. NFPA 10 – Portable Fire Extinguishers.

M. NFPA 13 – Installation of Sprinkler Systems.

N. NFPA 70 – National Electric Code.

O. NFPA 90A – Standard for Installation of Air Conditioning and Ventilating Systems.

P. NFPA 90B – Standard for Installation of Warm Air Heating and Air-Conditioning Systems.

Q. NFPA 101 – Life Safety Code.

R. SDI 100 – Recommended Specifications, Standard Steel Doors and Frames.

S. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings.

T. HOUSTON COMM. ECC – City of Houston Commercial Energy Conservation Code 2008.

1.03 SYSTEM DESCRIPTION

A. Building Names: Influent Pump Station Electrical Building and Chlorine Contact Basin Electrical Building.

1. Size: As shown on Drawings.
2. Roof Slope: 1 inch vertical to 12 inches horizontal. As shown on Drawings.
3. Include: Doors, door frames, door hardware and air conditioning units and other equipment as described herein, and as shown the Drawings.

B. System: Design, furnish, and install complete building package using manufacturer's standard components. Foundation to be constructed by General Contractor.

C. Structure: Pre-engineered, single-story, simple single-span, pre-cast concrete.

D. Design: Coordinate enclosure design with electrical and mechanical.

1.04 SUBMITTALS

A. Conform to Section 01330, Submittal Procedures.

B. Shop Drawings:

1. Manufacturer's Standard Details and Structural Calculations: Clearly mark those portions that apply to specific Project and those parts that do not apply.
2. Manufacturer's Literature and Technical Data: Drawings and Specifications for proposed building system.

3. HVAC Systems: Clearly marked penetrations for HVAC system showing location and size. Penetration locations and size shall be coordinated with the general contractor. The HVAC system is to be provided and installed by others. Refer to the mechanical drawings and Specification section 15730 for HVAC system specifications and performance requirements.
4. Painting Systems: Specifications including paint manufacturer's name, product trade-name, and preparation for shop and field coats.
5. Drawings stamped by Contractor's registered professional engineer and prepared specifically for this Project:
    a. Materials and Details: Show materials, details of components (including doors and other accessories), finishes, fastenings, methods of joining, sealants, anchor bolt, shear angle, connector plate, and base plate details, including all sizes and dimensions, size and location of structural elements and bracing.
6. Calculations Stamped by Contractor's registered Professional Engineer licensed in the State of Texas: Complete structural stress and deflection analysis of structural components and connections.
7. Informational Submittals:
    a. Experience records of manufacturer and installer.
    b. Approval of installer by manufacturer of structure components.
    c. Certification that codes and reference standards have been met.
    d. Description and details of electrical continuity and grounding methods.
    e. Test reports.

1.05 QUALITY ASSURANCE

A. Qualifications

1. Designers: Engineers registered in the State of Texas.
2. Manufacturer:
    a. At least 10 years' experience in work of the type required in this section.
    b. Fabricator must be a producer member of the National Precast Concrete Association (NPCA).
    c. Production capacity to provide work required for this Project without delay.
3. Erector/Installer:
    a. Not less than 5 years' experience in the erection of prefabricated structures similar to this project.
    b. Approved by manufacturer of building components.

B. Regulatory Requirements: Design building system to meet requirements of:

1. International Building Code; 2012 Edition (IBC).
2. ASHRAE 90.1 – 2007 with City of Houston Amendments, Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. International Energy Conservation Code: 2009 Edition (IECC) with City of Houston Amendments.
4. NFPA 101 Life Safety Code.
5. NFPA 70, National Electrical Code.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver building components in undamaged condition to Site only when ready for installation.

B. Protect products from damage and deterioration.

C. Handle products in accordance with manufacturers' instructions.

1.07 EXTRA MATERIALS

A. Delivery: In accordance with Section 01610, Basic Product Requirements.

PART 2 PRODUCTS

2.01 BUILDING SYSTEM MANUFACTURERS

A. Products of the following, meeting these Specifications, may be used on this Project: Lonestar Prestress Mfg. Inc., Houston, TX, 713-896-0994, or approved equal.

2.02 SYSTEM PERFORMANCE

A. Structural Loading: Design structure in accordance with ASCE 7-10 and the following:

1. Building: Own dead load.
2. Additional roof dead load of 15 psf for miscellaneous mechanical and electrical.
3. Special Equipment: As located on the Drawings.
4. Roof Live Load: 20 psf.
5. Design Wind Loads: Basic Wind Speed 145 mph (3 second gust) Exposure C. In accordance with the IBC.

6. Earthquake Load: In accordance with IBC for the project area. S_1=0.037, S_S=0.070, Soil Site Class D, Risk Category III, Design Category A, I=1.25
7. Ceiling Supporting Cable Tray System: 100 pounds per linear foot.

2.03 COMPONENTS

A. Substructure: Cast-in-place concrete foundation (by General Contractor).

B. Shell:

1. Provide weather tight structure that has straight, plumb walls with square corners.
2. Furnish louvers or ventilators as specified and as shown on the Drawings.
3. Slope roof to drain as shown on the drawings.
4. Furnish and install doors, frames, and hardware as specified and on the Drawings.

C. Interiors:

1. Floor: Base slab installed and finished by the General Contractor.
2. Walls: Vertical, smooth surface with minimum joints or seams, painted with scrubbable paint.
3. Flame Spread: ASTM E84 rating of 25 or less.

D. Roof: Roof panel shall slope as shown on the drawings. The roof shall extend a minimum of 2-3/4 inches beyond the wall panel on each side and be designed to prevent water migration into the building along top of wall panels. Roof shall have a standard smooth edge. Roof shall have a minimum R-value of R-20 to meet the International Energy Conservation Code - 2009. Install U-Channel Concrete inserts on underside of the roof panels with a length equal to the interior width of the building less 2 feet-0 inches. Inserts shall be at a uniform 4’-0” spacing for the length of the building to permit installation of miscellaneous electrical and mechanical equipment without the need for overhead drilling into roof panels.

E. Walls: Walls to be of an insulated precast concrete sandwich panel type. The walls shall have an extruded polystyrene core sandwiched between interior and exterior concrete wythes. The wall panels shall have a minimum thickness of 6”. Minimum wythe thickness shall be 2 inches. The walls shall have a minimum R-value of R-5.7 to meet the International Energy Conservation Code - 2009.

F. Floors: The floor shall have a minimum R-value of R-6.3 to meet the International Energy Conservation Code - 2009.

G. Plumbing Systems: Not required.

H. Air Conditioning: Air Conditioning equipment shall be provided by the General Contractor. Coordinate locations and openings to accommodate equipment.

I. Colors and Finishes:

1. As selected by Owner.
2. Exterior Shell: Easi-Brick finish, as shown on the Drawings.
3. Interior Walls: White.
4. Ceiling: White.
5. Door and Frames: Gray.
6. Interior Floors: Gray.

2.04 MATERIALS

A. Concrete: Furnish as specified in Section 03310, Structural Concrete with the additional requirement that the minimum 28 day compressive strength shall be 6000 psi.

B. Roofing: Manufacturer's standard 0.045" EPDM continuous membrane cemented to the rigid insulation on the top concrete surface with a compound designed for this purpose.

C. Sealant: Sikaflex-1A elastic sealant or equal.

D. Panel Connections: All panels shall be securely fastened together with 3/8-inch thick stainless steel brackets. Steel is to be of structural quality complying with ASTM A276, AISI Type 304 or 304L for welded construction. All fasteners to be 1/2-inch diameter stainless steel bolts complying with ASTM F573, AISI Type 316, condition CW. Cast-in anchors used for panel connections to be manufacturer's standard. All inserts for corner connections must be secured directly to form before casting panels. Floating of connection inserts will not be allowed.

E. U-Channel Concrete Inserts: Rolled ASTM A240/A240M, AISI Type 316 stainless steel, 0.105-inch thickness, 1-5/8-inch width by 1-3/8-inch depth, with stainless steel anchors at 10-inch maximum spacing, styrofoam fillers, and end caps. Nut and Bolt Hardware: Type 316 stainless steel, 5/8-inch minimum diameter, unless indicated otherwise. Manufacturer's standard to match insert. Manufacturers and Products: Power-Strut, Wayne, MI; PS 349 Series, B-Line Systems, Inc., Highland, IL; B32 Series, Halfen Anchoring Systems, Converse, TX; Channel Type 4141HTA, or equal.

F. SST Doors, Frames, and hardware:

1. Size: As shown on Drawings.
2. Furnish stainless steel doors and frames and transom panels.
3. Furnish hardware including hinges, cylindrical lock sets, exit devices keyed into Owner's existing system, automatic closing devices, full weatherstripping, and thresholds.

G. Finishes:

1. Interior Walls: System 4 in Section 9901, Protective Coatings
2. Interior Floors: Clear sealer.
3. Prepare bare concrete as recommended by Manufacturer.
4. Exterior walls and roof slab edge: System 4 in Section 09901, Protective Coatings.

2.05 SOURCE QUALITY CONTROL

A. Inspections: Before shipment, inspect for complete, functional assembly.

B. Test: Perform manufacturer's standard tests and adjustments on mechanical and electrical equipment and other moving and operating components.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Site and access to determine effect on proposed building.

3.02 PREPARATION

A. Verify Site conditions and make necessary field measurements.

B. Provide a 1-1/2-inch deep recess the width of the wall panel, or as required by building manufacturer, cast into the floor slab to prevent intrusion of water. Omit recess at the door locations.

3.03 ERECTION

A. Erect structural components in accordance with manufacturer's instructions. Securely anchor to concrete foundation.

B. Provide for erection and wind loads. Provide temporary bracing to maintain structure plumb and in alignment until completion of permanent, stable structure.

C. Install materials following manufacturers' instructions and recommendations.

3.04 FIELD FINISHING

A. Interior: As specified in Section 09901, Protective Coatings.

B. Exterior: As specified in Section 09901, Protective Coatings.

C. Do not paint electrical equipment.

3.05 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on moving and operating components.

3.06 MANUFACTURER'S SERVICES

A. Provide manufacturers' representatives at Site in accordance with Section 01755, Starting Systems, for installation assistance, inspection, and certification of proper installation.

3.07 CLEANING/ADJUSTING

A. Adjust moving and operating components for smooth operation.

B. Thoroughly clean interior and exterior of building and leave weathertight and ready for use.

3.08 PROTECTION

A. Protect installed products from damage.

END OF SECTION

Section 13300

PROCESS INSTRUMENTATION AND CONTROLS – GENERAL PROVISIONS

PART 1: GENERAL

1.01 SCOPE OF WORK

A. A pre-approved Process Control System Integrator (PCSI) shall furnish all services and equipment defined herein and in other specification sections as listed in Paragraph 1.03, Related Work.

B. All materials, equipment, labor, and services required to achieve a fully configured integrated and operational process control system shall be provided. The PCSI shall design and coordinate the process control system for proper operation with related equipment and materials furnished by other suppliers under other sections of these specifications and with related existing equipment. Application software programming for the Programmable Logic Controller (PLC) System and programming/graphics development for the HMI shall be performed by the Software Engineer (SE) as addressed in Specification 13441. Programming, configuration, and integration, including but not limited to Ethernet configuration and communications between all field I/O and PLC communications shall also be provided by the SE. In addition, the SE shall be responsible for providing all third party software/PLC code required to establish communication with the supplied hardware. <u>It shall be understood that when the PCSI is directed in this specification to provide any of the services reserved in this paragraph for the SE, the SE and not the PCSI shall provide those services</u>.

C. All configuration, integration, including but not limited to: loading of all software on computers, network equipment configuration, Ethernet configuration, and communications between servers and related equipment shall be provided by the SE. All programming of HMI and related equipment shall be by the SE. The PCSI shall furnish the operating system software and the application software.

D. Auxiliary and accessory devices necessary for system operation or performance to interface with existing equipment or equipment provided by other suppliers under other sections of these specifications, shall be included whether or not they are shown on the drawings. These devices include, but are not limited to, transducers, current isolators, signal conditioners, interposing relays, power supplies, and fiber optic transceivers.

E. Substitution of functions or type of equipment specified shall not be acceptable. In order to ensure parts are interchangeable, maintain quality, interface between the various subsystems, and establish minimums with regard to ranges and accuracy, strict compliance with the above requirements shall be maintained. System design shall allow

for the removal of individual devices from service without disrupting other devices in service.

F. Equipment shall be fabricated, assembled, installed, and placed in proper operating condition in full conformity with detail drawings, specifications, engineering data, instructions, and recommendations by the equipment manufacturer as approved by the Engineer.

G. The PCSI shall be responsible for calibrating all existing instruments that will interface with the new control system.

H. To facilitate the Owner's future operation and maintenance, products shall be by the same major manufacturer, with panel-mounted devices of the same type and model as far as possible.

I. The WWTP is an existing plant and all work shall be coordinated with its operating personnel to minimize impact on daily operation. Specifically, the contractor shall be responsible for providing a detailed daily plan to demonstrate how each of the PLCs shall be replaced or modified so that there is no operational down time experienced by the plant. This plan shall be a submitted for review and approval before any work is started on site. The actual sequence of the work is left to the contractor, but extensive pre-planning is necessary to accomplish the work. The following criteria must be used by the contractor when developing the PLC Replacement Plan:

1. PLC outages that result in more than one hour of operational downtime will not be allowed.

2. PLC outages of more than twice in an eight hour period will not be allowed.

3. Work on more than one PLC at a time will not be allowed.

4. The owner’s personnel will operate all equipment in the plant, and the contractor will not operate equipment. Such work to place specific equipment into MANUAL operation will need to be coordinated with the owner at least 24 hours in advance. In cases where there are no existing devices to place equipment into a constant running operation (i.e. no Hand-Off-Auto switch), then the contractor shall improvise by using temporary wiring.

5. The PCSI contractor will use temporary measures to ensure that the flow pacing signals used to meter chemicals are maintained at all times, regardless of which PLCs are out of service.

J. The WWTP is a fully operational facility monitored and controlled by local panels and PLCs. After the switch over, the PCSI must demonstrate that all new equipment and

reused existing equipment is connected to the new PLCs and the new computer system is fully functional as specified and shown on the Contract Drawings.

K. The Owner shall retain salvage rights to all material and equipment removed in the course of this work. All materials and equipment retained by the Owner shall be delivered to a point designated by the Owner in Houston, Texas. Any material or equivalent not retained by the Owner shall be removed from the site and disposed of by the General Contractor in accordance with applicable regulations and laws.

L. All equipment and installations shall satisfy applicable Federal, State, and local codes.

M. The Contract Drawings and related specification sections provide additional details showing building plan layouts, instrument device specifications, functional requirements of the system, and interfacing with other equipment.

N. All materials, equipment, labor, and services necessary to achieve the monitoring and control functions described herein shall be provided in a timely manner so that the monitoring and control functions are available when the equipment is ready to be placed into service.

O. The PCSI shall coordinate and schedule all required testing with the General Contractor, Owner, and Engineer.

P. The PCSI shall coordinate and schedule all required training with the General Contractor, Owner, and Engineer.

Q. The PCSI shall provide a monthly status report and updated project schedule to the General Contractor to be included in the General Contractor's overall project schedule.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be provided for work performed under this Section. Include the cost for this work in the lump sum base bid.

B. Refer to Section 01270 – Measurement and Payment.

1.03 RELATED WORK

A. The PCSI shall furnish all materials, labor, and services specified in the following specification sections as required ensuring that a single, coordinated system is supplied:

1. Section 13315 – Process Instrumentation and Controls - Products

2. Section 13325 – Control Panels and Panel Mounted Equipment

3. Section 16195 – Electrical Identification

B. Divisions requiring coordination shall include, but not be limited to, the following:

1. Division 1 - General Requirements

2. Division 13 - Special Construction

3. Division 15 - Mechanical

4. Division 16 - Electrical

C. The PCSI shall coordinate with all equipment suppliers, mechanical subcontractor, electrical subcontractor, and General Contractor.

1.04 COORDINATION MEETINGS

A. A. The PCSI shall schedule and administer a minimum of three mandatory coordination meetings. The PCSI shall make arrangements for meetings; prepare agenda with copies to participants at least one week before scheduled meetings. The meetings will be conducted at the WWTP and shall include, as a minimum, attendance by the Owner, Engineer, General Contractor's project engineer, PCSI's project engineer, and the electrical subcontractor.

1. The first coordination meeting shall be held in advance of the first PCSI shop drawing submittal. The purpose of the first meeting shall be for the PCSI to:

a. Summarize their understanding of the project

b. Discuss any proposed substitutions or alternatives

c. Schedule testing and delivery milestone dates

d. Provide a forum for the PCSI to coordinate hardware and software related issues

e. Request any additional information required from the Owner and/or Engineer.

f. The PCSI shall bring a draft version of shop drawings to the meeting to provide the basis for the Owner/Engineer's input into their development.

2. The second coordination meeting shall be held after the Field Instruments, Digital System Hardware, and Control Panels and Panel Mounted Equipment shop drawing

submittals have been reviewed by the Engineer and returned to the PCSI. The purpose of the second meeting is to:

a. Discuss comments made on the submittal packages

b. Refine scheduled milestone dates

c. Coordinate equipment installation activities

3. The last coordination meeting shall be held one month prior to factory acceptance testing. The purpose of the last coordination meeting is to discuss any remaining coordination requirements.

4. A typical agenda may include, but is not limited to, the following:

a. Review minutes of previous meetings

b. Review of work progress

c. Field observations, problems, and decisions

d. Identification of problems, which impede planned progress

e. Review of submittal schedule and submittal status

f. Review of off-site fabrications and delivery schedules

g. Maintenance of progress schedule

h. Corrective measures to regain projected schedules

i. Planned activities for subsequent work period

j. Coordination of projected progress

k. Maintenance of quality and work standards

l. Effect of proposed changes on progress schedule and coordination

m. Other business relating to project

B. The costs associated with the coordination meetings, including auto expenses, meal expenses, etc., shall not be included as part of the work of this section.

1.05 SUBMITTALS

A. Submit shop drawings in accordance with Section 01300, Submittals. The shop drawings shall fully demonstrate that the equipment and services to be furnished comply with the provisions of these specifications and provide a true and complete record of the equipment as manufactured and delivered. Each submittal shall be securely bound with an index and sectional dividers. All submittal drawings shall be legible and shall be 11 inches x 17 inches.

B. The Engineer shall determine whether a product is an "Approved Equal" based upon the information listed herein and the manufacturer's data sheets regarding the models specified. Alternate equipment must meet the criteria listed herein and any additional information in the manufacturer's data sheets in order to be accepted as an "Approved Equal". Supplier must furnish five working installation references for any alternate equipment along with owner, contact, and telephone number.

C. The submittals listed below shall be provided as a minimum. Other specification sections may require other submittals not listed here. Each submittal must be complete. No partial submittals will be accepted.

1. System Input/Output List

2. Project Plan

3. The project plan shall be submitted and approved before any additional submittals (except I/O List) will be accepted.

4. Field Instruments

5. Digital System Hardware

6. Control Panels and Panel Mounted Equipment

7. Testing

8. Training

9. Loop Diagrams

10. Spares, Expendables, and Test Equipment

11. Operation and Maintenance (O&M) Manuals

D. Submittal Descriptions

1. System Input/Output List

a. Within 90 days of the contract award, the PCSI shall submit a System Input/Output List submittal containing a complete system Input/Output (I/O) list for equipment connected to the control system under this Contract. The I/O list shall be submitted in a Microsoft Excel electronic file format on a CD ROM and an 8 1/2-inch by 11-inch hard copy. The hard copy list shall be sorted first by ISA tag name and second by I/O type (i.e., AI, AO, DI, DO, etc.). The list shall contain, as a minimum, the following for each active point and spare point:

(1) Tag name

(2) Type of I/O (i.e., DI, DO, AI or AO)

(3) I/O point address (PLC name/address and point address)

(4) Point name (or SPARE)

(5) Point description

(6) High/Low range and engineering units

(7) Alarm limits

(8) Relay normal status contact configuration

(9) I/O terminal point physical location (panel name, rack, slot etc.)

(10) 2-wire or 4-wire instrument.

2. Project Plan

a. The Project Plan shall provide an overview of the proposed system including system architecture drawing, approach to work, proposed work schedule indicating milestones and potential meetings, project personnel and organization, details of factory testing and field testing, and details of training program. The Project Plan shall also include an acknowledgment of conformance to the specification on a paragraph-by-paragraph basis indicating any proposed deviations. The schedule shall be coordinated with the project execution schedule and illustrate all major project milestones including the following:

(1) Schedule for all subsequent project submittals

(2) Schedule for all project design review meetings

(3) Schedule for manufacture, assembly and staging of all process control system equipment

(4) Schedule for all tests

(5) Schedule for shipment of all process control system equipment and peripheral devices

(6) Schedule for equipment start-up

(7) Schedule for all training

3. Existing System Replacement Work Plan

a. Provide in detail a step-by-step switchover plan from the existing system to the new PC/PLC-based monitoring and control system for the existing plant.

b. The submittal shall provide the coordination details among Owner, General Contractor, and subcontractors that may be affected by the switchover plan.

c. The submittal shall include a switchover schedule.

4. Field Instruments

a. This submittal shall provide complete documentation of all field instruments using ISA-S20 format. A complete Bill of Materials (BOM) listing all instrumentation equipment shall be provided.

b. Data Sheets

(1) Provide data sheets for each instrument listing model numbers, options, and ancillary devices that are being provided. The data sheets shall be provided with an index, proper identification, and cross-referencing. The data sheets shall include, but not be limited to, the following information:

(2) Plant Equipment Number and ISA tag number per the Loop Diagrams

(3) Product (item) name used herein and on the Contract Drawings

(4) Manufacturer's complete model number

(5) Location of the device

(6) Input output characteristics

(7) Range, size, and graduations

(8) Physical size with dimensions, enclosure NEMA classification and mounting details

(9) Materials of construction of all components

(10) Instrument sizing calculations where applicable

(11) Certified calibration data for all flow metering devices

c. Equipment Specification Sheets

(1) Provide equipment specification sheets, which, shall fully describe the device, the intended function, how it operates and its physical environmental and performance characteristics. Each data sheet shall have appropriate cross references to loop or equipment identification tags. As a minimum the specification sheets shall include the following:

a) Dimension, rigid clearances

b) Mounting or installation details

c) Connection

d) Electrical power or air requirements

e) Materials of construction

f) Environmental characteristics

g) Performance characteristics

h) Complete information regarding the field instruments as required by ISA-S5.4 standards shall be provided under this contract.

5. Digital System Hardware

   a. This submittal shall provide complete documentation of the proposed hardware (PLC's, IO's, communication equipment, cables, peripherals, etc.) A complete BOM listing all digital hardware equipment shall be provided.

   b. The submittal shall include the following:

      (1) System Block Diagram

      A complete schematic system block diagram(s) showing the interconnections between major hardware components including, but not limited to:

      a) Control centers

      b) Panels

      c) Power supplies

      d) Consoles

      e) Computer and peripheral devices

      f) Telemetry equipment

      g) Local digital processors and like equipment

      h) Uninterruptible Power Supplies (UPS)

      (2) The block diagram shall reflect the total integration of all digital devices in the system and any human machine interface (HMI) locations. Location of all components shall be clearly identified with appropriate cross-references.

      (3) The diagram shall reference all interconnecting cabling requirements for digital components of the system including any data communication links.

   c. Data Sheets

      (1) A data sheet for each hardware component listing all model numbers, options, auxiliary and ancillary devices that are being provided.

      (2) The data sheets shall be provided with an index, proper identification, and cross-referencing. They shall include, but not be limited to, the following information:

a) Equipment Number and ISA tag number

b) Product (item) name used herein and on the Contract Drawings

c) Manufacturer's complete model number

d) Location of the device

e) Input/output characteristics

f) Range, size, and graduations

g) Physical size with dimensions, enclosure NEMA classification and mounting details

h) Materials of construction of all components

i) Power supply device sizing calculations where applicable

d. The Digital System Hardware submittal shall also contain all planning information, site preparation instructions, grounding and bonding procedures, cabling diagrams, plug identifications, safety precautions or guards, and equipment layouts in order to enable the General Contractor to proceed with the detailed site preparation for all equipment.

6. Control Panels and Panel Mounted Equipment

a. This submittal shall provide complete documentation of all panel instruments, control panels, and control equipment not submitted elsewhere. A complete BOM listing all instrumentation and control equipment shall be provided.

b. Provide data sheets for each component listing all model numbers, options, and ancillary devices that are being provided. The data sheets shall be provided with an index, proper identification, and cross-referencing. The data sheets shall include, but not be limited to, the following information:

(1) Plant Equipment Number and ISA tag number

(2) Product (item) name used herein and on the Contract Drawings

(3) Manufacturer's complete model number

(4) Location of the device

(5) Input - output characteristics

(6) Range, size, and graduations

(7) Physical size with dimensions, enclosure NEMA classification and mounting details

(8) Materials of construction of all components

(9) Panel instrument or control device sizing calculations where applicable

c. Provide equipment specification sheets, which shall fully describe the device, the intended function, how it operates, and its physical environmental and performance characteristics. Each equipment specification sheet shall have appropriate cross references to loop or equipment identification tags with model number and information pertaining to the item highlighted. As a minimum the specification sheets shall include the following:

(1) Dimension, rigid clearances

(2) Mounting or installation details

(3) Connection

(4) Electrical power or air requirements

(5) Materials of construction

(6) Environmental characteristics

(7) Performance characteristics

d. Provide detailed drawings covering control panels, consoles and/or enclosures, which shall include:

(1) Cabinet assembly and layout drawings to scale. Drawings shall include both front and interior subpanel layouts.

(2) Material, fabrication, and painting specifications

(3) Color selection samples for selection by the Engineer

(4) Where graphic display panels are required, submit detailed layouts to scale, including symbols and line widths, as well as color selection samples and details of fabrication. Half-scale layouts shall be acceptable.

(5) Panel wiring diagrams showing all power connections to equipment within and on the panel, combined panel power draw requirements (volts, amps), breaker sizes, fuse sizes, and grounding. This wiring diagram shall be in ladder logic format and shall reference the appropriate loop drawing for continuations or details where required. Show all wire numbers and terminal block designations.

e. The submittal shall also contain all planning information, site preparation instructions, grounding and bonding procedures, cabling diagrams, plug identifications, safety precautions or guards, and equipment layouts in order to enable the General Contractor to proceed with the detailed site preparation for all equipment.

f. The submittal shall also include heat dissipation calculations for each enclosure.

7. Testing

a. A test plan shall be submitted after the Owner and/or Engineer have approved all hardware submittals. The test plan shall demonstrate that the PCSI has designed and configured a system that meets the design specifications. The test plan shall be submitted prior to the preparation of the detailed test procedures and submit outlines of the specific proposed tests. Submittals shall include examples of the proposed forms and checklists.

b. The system shall be tested using the system architecture drawing and a Bill of Materials of all hardware indicating manufacturer, model, and serial number. The documents for the test plan shall be structured so that the Engineer understands what the inputs are, what the predicted outputs should be and what the actual outputs are. The test plan shall have a sign off and date block for the PCSI, General Contractor, Owner, and Engineer.

c. The test plan should include the following as a minimum:

(1) A BOM listing control system components' manufacturer, model and serial number.

(2) System hardware summary

(3) A testing schedule describing the specific tasks to be performed and the time allotted for each task

(4) Communications tests to the various PLCs for discrete and analog I/O data transfer

(5) 100 percent I/O point test including all spare points based upon the previously submitted system I/O list

d. Test procedures shall be submitted after the test plan submittal has been reviewed by the Engineer and returned stamped either Approved or Approved as Noted, Confirm. The submittal shall document the proposed procedures to be followed during the test. Procedures shall include test descriptions, forms, and checklists to be used to control and document the required tests. Testing shall not be started until all Testing Submittals have been approved.

e. For Test Documentation, submit a copy of the signed off test procedures upon completion of each required test.

8. Training

a. Submit an overview of the proposed training plan. Each proposed course shall include:

(1) An overview of the training plan explaining why specific courses are proposed

(2) Course title and objectives

(3) Prerequisite training and experience of attendees

(4) Recommended attendees

(5) Course Content - A topical outline

(6) Course Duration

(7) Course Location - Training center or jobsite

(8) Course Format - Lecture, laboratory demonstration, etc.

b. The Engineer shall review the preliminary training plan submittal with the Owner.

c. Upon receipt of the Owner's and Engineer's comments on the preliminary training plan, submit the specific proposed training plan. The training plan shall include:

(1) Definition of each course

(2) Specific course attendance

(3) Schedule of training courses including dates, duration, and location of each class

(4) Resumes of the instructors who will actually conduct the training

9. Loop Diagrams

a. Provide detailed loop diagrams on single 11 inches x 17 inches or 8.5 inches x 11 inches sheets for each monitoring or control loop. The submittal shall also be submitted in electronic format on a CD-ROM. The loop diagrams shall show all components of the loop both analog, digital, and discrete including all relays, switches, dropping resistors, etc. which are being provided for proper operation. Loop numbers used shall correspond to the loop numbers indicated in the contract documents. The format shall be the Instrument Society of America, Standard for Instrument Loop Diagrams, ISA-S5.4, and the following requirements:

(1) On each diagram present a tabular summary of:

a) The output capability of the transmitting instrument

b) The input impedance of each receiving instrument

c) Estimate of the loop wiring impedance based on wire sizes and approximate length used

d) The total loop impedance

e) Reserve output capacity

(2) Show all interconnecting wiring between equipment, panels, terminal junction boxes and field mounted components. The diagrams shall show all components and panel terminal board identification numbers and all wire numbers. This diagram shall include all intermediate terminations between field elements and panels (e.g., terminal junction boxes). The diagrams shall be coordinated with the electrical contractor and bear mark showing this has been done.

(3) Show location of all devices

(4) Show instrument description showing type, manufacturer, model number, range, setpoints, and operation (e.g., fail open, open on energization, normally closed, etc.) as applicable.

(5) Show all instrument loop power or instrument air requirements back to termination on terminal block or bulkhead, fuse blocks (including fuse size), etc., as applicable.

(6) Show all grounding points within cabinets and panels and identify the connection point of individual components.

(7) Complete information regarding the field instruments as required by ISA-S5.4 standards shall be provided on the loop diagrams under this contract.

10. Spares, Expendables, and Test Equipment

a. This submittal shall include the following for each Subsystem:

(1) A list of, and descriptive literature for, spares, expendables, and test equipment as specified in Instrumentation Sections.

(2) A separate list of, and descriptive literature for, additional spares, expendables, and test equipment recommended by the PCSI

(3) Unit and total cost for the additional spare items recommended for each subsystem

(4) Storage instructions for all spare parts

(5) Any specialty software or hardware tools used during configuration of the project.

NOTE: These specialty tools must be turned over to the Owner.

11. Operation and Maintenance (O & M) Manuals

a. Provide O & M Manuals per section 13300-1.12.

b. The submittal shall also be submitted in electronic format on a CD-ROM

1.06 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM).

1. ASTM A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.

B. Instrument Society of America (ISA)

1. ISA S5.2 - Binary Logic Diagrams for Process Operations

2. ISA S5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation Logic and Computer Systems.

3. ISA S5.4 - Instrument Loop Diagrams

C. American National Standards Institute (ANSI)

1. ANSI X3.5 - Flowchart Symbols and Their Usage in Information Processing

D. National Electrical Manufacturers Association (NEMA)

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.07 PCSI QUALIFICATIONS

A. The PCSI shall perform all work necessary to select, furnish, configure, customize, debug, install, connect, calibrate, and place into operation all hardware and software specified within this specification and other related divisions of this specification.

B. The PCSI shall be a “systems house” regularly engaged in the design and installation of computer systems and their associated subsystems as they apply to the municipal water or wastewater industry. For the purposes of this specification section, a “systems house” shall be interpreted to mean an organization that complies with all of the following criteria:

1. Employs a Texas Registered Professional Control Systems Engineer or Texas Registered Professional Electrical Engineer to supervise or perform the work required by this specification section.

2. Employs personnel on this project who have successfully completed a manufacturer’s training course on the configuration and implementation of the specific programmable controllers, computers, and software proposed for this project.

3. Has performed work of similar or greater complexity on at least three projects within the last five years and has implemented and completed at least one of the three projects with the proposed HMI software.

4. Has been in the water/wastewater industry performing the type of work specified in this specification section for a minimum of five continuous years.

C. The PCSI shall maintain a fully equipped office/production facility with full time employees capable of fabricating, configuring, installing, calibrating, troubleshooting, and testing the system specified herein. Qualified repair personnel shall be available and capable of reaching the facility within 24 hours.

D. Actual installation of the system need not be performed by the PCSI's employees; however, the PCSI shall provide the onsite technical supervision of the installation.

E. The PCSI shall furnish equipment which is the product of one manufacturer to the maximum practical extent. Where this is not practical, all equipment of a given type shall be the product of one manufacturer.

F. The General Contractor must select a pre-approved PCSI from the list below. Only pre-approved PCSI companies are accepted.

BL Technology, Inc.
13171 Misty Willow Drive
Houston, TX, 77070
Attn: Robert Lee
Phone: 281-970-8191

Boyer Inc.
8904 Fairbanks N. Houston
Houston, TX 77064
Attn: Stacy Jordan
Phone: 713-466-5395

MCC Weimar
Weimar Manufacturing
505 South Eagle Street
Weimar, TX 78962
Attn: Frank Macaulay
Phone: 979-725-8527

Prime Controls, LP
10400 Westoffice
Suite 105
Houston, TX 77042
Attn: Mike Whitman
Phone: 713-244-9747

G. Being listed in this specification section does not relieve any potential PCSI from meeting the qualifications specified in this section.

H. Listed PCSI companies are not required to submit a qualification proposal. Companies interested in being pre-approved as a PCSI, shall submit three (3) copies of a qualification proposal to the Engineer no later than two weeks before the bid opening date. Additional pre-approved PCSI companies will be listed by Addendum no later than seven (7) days before the bid opening date.

1. The qualification proposal shall provide details and a description of how the supplier proposes to fulfill the requirements set forth in this Specification. The supplier shall present the proposal in sufficient detail so that proper evaluation regarding the experience and capabilities of the supplier can be performed.

   a. The proposal shall contain evidence that the supplier has sufficient financial resources to meet the obligations incidental to the performance of the work including available bonding. (This requirement may be provided in the form of a verifiable or certified financial report for the company's latest fiscal year).

   b. The proposal shall contain a list of personnel available for assignment to the responsible positions of Project Manager, Project Engineer, Lead Programmer, Installation Supervisor, and Area Service Representative. Also, include a concise resume of each individual's education, work experience, and accomplishments.

   c. The proposal shall contain the following specific information:

      (1) Maintenance services available for hardware and software: Evaluation will be based on the supplier's capability to provide the required routine and emergency services. The supplier's proposal is to describe the capabilities and location of his/her nearest (to job site) service organization. It is the intent of the Specification to obtain all system maintenance services from the supplier. If the supplier intends to subcontract all or portions of the service requirements, it must be stated as such along with the name and address of the organization.

      (2) Technical validation examples of recently completed and similar scope projects: The supplier shall provide information regarding type, size,

complexity, and performance of five (5) systems recently completed, along with names, addresses, and telephone numbers of persons qualified to verify supplier's statements approximate cost of the instrumentation system supplied, project completion date and description. Evaluation shall be based on the similarity of system requirements and supplier's performance.

(3) A description of how the supplier plans to execute the various functions and locations where the various portions of the work will be performed, coordinated and managed (e.g., design, engineering, manufacturing, programming, testing and scheduling). The vendor is required to state in his/her proposal those functions, which he/she intends to subcontract to other organizations and include the name, address and capabilities of these organizations.

d. The supplier shall be required to demonstrate a minimum of five (5) years recent, past experience in the design, manufacture and commissioning of instrumentation and control systems of comparable size, type and complexity to the proposed project. The supplier shall be required to have his/her own in house capability to handle complete system engineering, fabrication, and testing.

e. The supplier shall indicate that he/she has in his/her employ capable personnel for detailed engineering, coordination, drafting, procurement and expediting, scheduling, construction, testing, inspection, installation, training start up service for calibration and commissioning and warranty compliance for the period specified.

1.08 DELIVERY, STORAGE AND HANDLING

A. Provide Delivery, Storage, and Handling requirements per Specification Section 01600 and as specified below:

B. Shipping Precautions

1. After completion of shop assembly, factory test, and approval, all equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weights shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at jobsite.

2. Special instructions for proper field handling, storage, and installation required by the manufacturer for proper protection, shall be securely attached to the packaging for

each piece of equipment prior to shipment. The instructions shall be stored in resealable plastic bags or other acceptable means of protection.

3. None of the control equipment shall be shipped to the site until the room(s) are environmentally suitable.

C. Identification

1. Each component shall be tagged to identify its location, tag number and function in the system. Identification shall be prominently displayed on the outside of the package.

2. Each piece of equipment supplied shall have a permanent stainless steel tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the Drawings.

D. Storage

1. Equipment shall not be stored out of doors. Equipment, including in line equipment, shall be stored in dry permanent shelters and adequately protected against mechanical injury. If any apparatus has been damaged, the General Contractor, at his own cost and expense, shall repair such damage. If any equipment has been subject to possible damage by water, it shall be thoroughly dried and put through such tests as directed by the Engineer. Any repair or replacement shall be at the cost and expense of the General Contractor.

1.09 PROJECT/SITE REQUIREMENTS

A. Environmental Requirements. Air-conditioned areas require NEMA Type 12 ventilated enclosures. Equipment below grade shall be NEMA Type 4X. All other areas require NEMA Type 4X stainless steel enclosures. Refer to Division 16 for area environmental hazardous classifications. All instrumentation enclosures and all instruments mounted outdoors shall be furnished with sun shields.

B. Elevation. Equipment shall be designed to operate at a ground elevation of approximately 1500 feet above mean sea level.

C. Temperature. Indoor areas' equipment shall be suitable for 10 to 35 C degrees ambient. Outdoor areas' equipment shall be suitable for 30 to 50 C degrees ambient. Storage temperatures shall range from zero to 50 C degrees ambient. Additional cooling or heating shall be furnished if required by the equipment.

D. Relative Humidity. Air-conditioned area equipment shall be suitable for 20 to 95 percent relative, non condensing humidity. All other equipment shall be suitable for 0 to 100 percent relative, condensing humidity.

E. Power Supply. 120 volts AC sources of electric supply shall be unregulated industrial panel boards.

1.10 MAINTENANCE

A. Spare Parts

1. Spare parts shall be as defined in the related specification sections. All spare parts shall be new and unused.

2. All spare parts shall be individually packaged and labeled.

3. Provide one (1) gallon of touch up paint, in one quart containers, for each type and color used for all cabinets, panels, consoles, etc., supplied under the related specification sections.

4. The spares listed above shall be packed in a manner suitable for long term storage and shall be adequately protected against corrosion, humidity, and temperature.

1.11 WARRANTY

A. Provide equipment warranties per Section 01740, Warranties and Bonds, and herein.

1.12 O & M MANUALS

A. Prior to final acceptance of the system and owner training, operating and maintenance manuals covering instruction and maintenance on each type of equipment shall be furnished in accordance with Section 01730, Operating and Maintenance Data.

B. The instructions shall be bound in three ring binders with Drawings reduced or folded for inclusion and shall provide the following as a minimum:

1. A comprehensive index

2. A complete "As Constructed" set of approved shop Drawings

3. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data

4. Full specifications for each item

5. System schematic drawings "As Constructed," illustrating all components, piping and electrical connections of the systems supplied under this Section

6. Detailed service, maintenance, and operation instructions for each item supplied

7. Special maintenance requirements particular to this system clearly defined, along with special calibration and test procedures

8. Operating instructions which incorporate a functional description of the entire system, with references to the systems schematic Drawings and instructions

9. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier

C. The final documentation shall be new documentation written specifically for this project, but may include standard and modified standard documentation. Modifications to existing hardware or software manuals shall be made on the respective pages or inserted adjacently to the modified pages. All standard documentation furnished shall have all portions that apply clearly indicated. All portions that do not apply shall be lined out.

D. The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

E. If the PCSI transmits any documentation or other technical information, which he considers proprietary, such information shall be designated. Documentation or technical information which is designated as being proprietary will be used only for the design, construction, operation, or maintenance of the system and, to the extent permitted by law, will not be published or otherwise disclosed.

F. The final documentation requirements are as follows:

1. As-built documentation shall include all previous submittals, as described in this Specification, updated to reflect the as built system. Any errors in or modifications to the System resulting from the Factory and/or Field Acceptance Tests shall be incorporated in this documentation.

2. The Hardware Maintenance documentation shall describe the detailed preventive and corrective procedures required to keep the System in good operating condition. Within the complete Hardware Maintenance documentation, all hardware

maintenance manuals shall make reference to appropriate diagnostics, where applicable, and all necessary timing diagrams shall be included. A maintenance manual or a set of manuals shall be furnished for all delivered hardware, including peripherals. The Hardware Maintenance documentation shall include, as a minimum, the following information:

a. Operation Information - This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.

b. Preventive Maintenance Instructions - These instructions shall include all applicable visual examinations, hardware testing, diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the System.

c. Corrective Maintenance Instructions - These instructions shall include guides for locating malfunctions down to the card replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction.

d. Parts Information - This information shall include the identification of each replaceable or field repairable module. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross references between the Instrumentation System Supplier's part number and manufacturer's part numbers shall be provided.

e. System Backup/Restore - This information shall include a detailed description of the procedure for backing up the computer system (including PC and PLC); reloading using a backup; and completely restoring a PC and/or PLC from a backup.

1.13 PROGRAMMING

A. Schedule a meeting with Craig Lewis (713-775-2636) or other designated City personnel to discuss PLC programming philosophy for the project.

B. Program PLCs to reflect the philosophy provided by Craig Lewis.

C. Schedule a meeting with Craig Lewis or other designated City personnel to review programming.

D. After new PLCs are operational, schedule a meeting again with Craig Lewis or other designated City personnel to review operation of PLCs.

E. Programming and Graphics Development for Added I/O

1. PLCs and local iFix HMIs shall be programmed for added I/O. Graphics development shall be provided to update existing OITs (Operator Interface Terminals) and PCs.

2. Alarming and historical logging shall be provided for all added I/O.

3. The Groveway iFix SCADA shall be programmed and HMI graphics developed for all added I/O.

F. I/O Modules and I/O Racks

1. Provide I/O modules for all added I/O. Added modules to match existing modules in each PLC.

2. Where an existing I/O rack does not have space for the required number of I/O modules, replace the I/O rack with a larger I/O rack.

G. Programming and Graphics Development

1. PLCs and local iFix HMIs shall be programmed for new I/O. Graphics development shall be provided to update existing OITs (Operator Interface Terminals) and PCs.

2. Alarming and historical logging shall be provided for all new I/O.

3. The Groveway iFix SCADA shall be programmed and HMI graphics developed for all new I/O.

PART 2: PRODUCTS

2.01 GENERAL

A. Process Control System:

1. All instrumentation supplied shall be of the manufacturer's latest design and shall produce or be activated by signals that are established standards for the water and wastewater industries.

2. All electronic instrumentation shall be of the solid state type and shall utilize linear transmission signals of 4 to 20 mA DC (milliampere direct current), however, signals between instruments within the same panel or cabinet may be 1-5V DC (volts direct current), or the like.

3. Output of equipment not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero-based signals will be allowed.

4. All instruments shall be provided with mounting hardware, floor stands, wall brackets, or instrument racks as shown on the Drawings or as required.

5. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Electrical Drawings, to comply with the National Electrical Code.

6. All indicators and recorder readouts shall be linear in process units, unless otherwise noted.

7. All transmitters shall be provided with either integral indicators or conduit mounted indicators in process units, accurate to two percent (2%).

8. Electronic equipment shall be of the manufacturer's latest design, utilizing printed circuitry and suitably coated to prevent contamination by dust, moisture and fungus. Solid state components shall be conservatively rated for their purpose to assure optimum long-term performance and dependability over ambient atmosphere fluctuations and 0 to 95% percent relative humidity. The field mounted equipment and system components shall be designed for installation in dusty, humid, and slightly corrosive service conditions.

9. All equipment, cabinets, and devices furnished hereunder shall be heavy duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.

10. The field mounted digital system equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.

11. All electronic/digital equipment shall be provided with radio frequency interference protection and shall be FCC approved.

B. Electrical

1. All equipment shall be designed to operate on a 60 Hertz alternating current power source at a nominal 120 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

2. Panels containing networking equipment and PLC equipment shall be powered by two separate 24VDC power supplies. One pair of redundant 24VDC power supplies shall be furnished for the networking equipment and a separate pair of redundant 24VDC power supplies shall be furnished for loop powered instrumentation devices and PLC equipment.

3. Materials and equipment used shall be UL approved wherever such approved equipment and materials are available.

4. All equipment shall be designed and constructed so that in the event of a power interruption, the equipment specified hereunder shall resume normal operation without manual resetting when power is restored.

2.02 LIGHTNING/SURGE PROTECTION

A. Lightning/Surge protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and be maintenance free and self-restoring. Instruments shall be housed in a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground, and where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the instrument enclosure or a separate NEMA 4 junction box coupled to the enclosure.

B. Either a two or three-stage protection circuit, depending on the application, shall furnish I/O protection.

C. All wiring, hardware, and connection means shall comply with the National Electric Code and/or applicable local codes.

D. All suppressors shall have integral mounting brackets to attach 35mm DIN rail conforming to DIN EN50022, with the exception of conduit mounted devices.

E. The suppressor shall be mounted as close to the equipment it is protecting as possible.

F. Mounting guidelines will be followed as indicated in installation instruction provided by the manufacturer.

G. Wires shall be attached to the suppressor by means of a cable-clamping terminal block activated by a screw. Connections shall be gas-tight, and the terminal block shall be fabricated of non-ferrous, non-corrosive materials.

H. All wiring points and plug connections shall be "touch safe" with no live voltages that can make contact with a misplaced finger in accordance with IEC 529.

I. Analog and discrete and data protection DIN rail mounted, pluggable devices shall meet the following.

1. Surge suppression modules for 24V and 110V circuits shall be UL listed or recognized.

2. Surge protection shall consist of a multistage hybrid circuit with staging inductors or resistors to properly coordinate the components.

3. DIN rail mounted surge protection modules shall consist of two parts; a base terminal block and a plug protection module. Replacing a plug shall not require the removal of any wires nor shall it interrupt the signal. Base and plug shall have the ability to be coded to accept only the correct voltage plug.

4. Surge protection for analog or discrete I/O shall be designed to withstand a maximum 10 kA test current of a 8/20 microsecond waveform according to IEC 1024 Application Guide A and ANSI/IEEE C62.41 Category C Area.

5. Surge protection for hazardous area locations will conform to EN 50 020/DIN EN 50 020/VDE 0170/0171 part 7: 1996-04. Surge protection for hazardous areas shall have at least 500V isolation between intrinsic safety ground and earth ground.

6. Both plugs and bases shall have a rating of IP20 according to IEC 529. Bases shall have an integral label holder to mark each terminal block.

7. Operating temperature range shall be at least -40°C to +80°C.

8. Bases shall include metal mounting foot, which provides ground connection to DIN-rail.

9. Manufacturers:

   a. Analog: Phoenix Contact model series PT 2 x 2. One plug and base required for two analog loops. Discrete 5-24V: Phoenix Contact model series PT 4 x 1. One plug and base required for every four discrete signals. Discrete 60-230V: Phoenix Contact model series PT 2 x 1 VA. One plug and base required for every two discrete signals.

   b. Dehn, with models to match the Phoenix Contact device ratings.

   c. Approved Equal.

J. Analog and discrete DIN rail mounted, non-pluggable, high density devices shall meet the following

1. Surge protection shall consist of a multistage hybrid circuit with staging inductors or resistors to properly coordinate the components. Series resistance shall not exceed 4.7 ohms (+/- 10%).

2. DIN rail mounted surge protection housing width shall not exceed 6.2mm.

3. Surge protection for analog and digital I/O shall be designed to withstand a 5 kA test current of a (8/20)s waveform according to IEC 1024 Application Guide A and ANSI/IEEE C62.41 (Line to Ground). Surge handling capability of Line 1 + Line 2 shall be 10 kA of (8/20)s waveform.

4. Operating temperature range shall be at least -40C to +85C.

5. Maximum load current through the surge protection module shall not exceed 250 milliamps for analog and digital signal protection.

6. Cutoff frequency for analog modules shall be 3 MHz for a 50-ohm system and 1 MHz for a 150-ohm system. Cutoff frequency for digital modules shall be 2 MHz for a 50-ohm system and 600 KHz for a 150-ohm system.

7. Wire size range shall between 24 and 14 AWG.

8. Ex-I modules shall contain only diode and gas tube (no MOV) and shall be isolated from ground by 500VDC as required by EN 50 020.

9. Manufacturers

   a. Phoenix Contact model series TT-2-PE-24DC, TT-2/2-24DC, or TT-EX(I)-24DC. Phoenix Contact model series PT 2 x Ex(I)-24DC. One plug and base required for two analog loops or four discrete signals.

   b. Dehn, with models to match the Phoenix Contact device ratings.

   c. Approved Equal.

K. Analog Signals (Conduit Mounted)

1. Surge protection shall consist of a multistage hybrid circuit utilizing only diodes and gas discharge tubes but no metal oxide varistors (MOVs).

2. Surge protection for analog and digital I/O shall be designed to withstand a 10 kA test current of a (8/20) µs waveform according to IEC 1024 Application Guide A and ANSI/IEEE C62.41 Category C Area.

3. Surge protection shall not have more than 10 ohms of series resistance.

4. Surge protection shall have a response time less than 1µs.

5. Maximum operating voltage shall not exceed 28 VDC.

6. Surge protection shall not have a cutoff frequency less than 400kHz (for a 600 ohm system) to allow HART protocol and other superimposed smart digital signals to function.

7. Surge protection module shall have an operating temperature range of at least -40°C to +65°C.

8. Maximum load current through the surge protection module shall not exceed 250 mA.

9. Manufacturers:

    a. Phoenix Contact model series PIPETRAB. Protection circuit is mounted in 3/4" stainless steel pipe nipple.

    b. Dehn, with models to match the Phoenix Contact device ratings.

    c. Approved Equal.

PART 3: EXECUTION

3.01 GENERAL INSTALLATION

A. The process control system, instrumentation, and accessory equipment shall be installed in accordance with the manufacturer's instructions. The locations of equipment, transmitters, alarms, and similar devices shown on the drawings are approximate only. Exact locations shall be as approved by the Engineer during construction. All information relevant to the placing of process control work shall be obtained in the field. In case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

B. Two complete sets of approved shop drawings shall be kept at the job site during all on site construction. Both sets shall be marked up identically to reflect any modifications

made during field installation or start up. All markings shall be verified and initialed by the Engineer or his designated representative.

C. Following completion of installation and the Operational Readiness Test, one set of the marked up drawings shall be provided to the Engineer; the other set shall be retained by the Supplier for incorporation of the mark ups into final as built documentation.

D. The instrumentation installation details on the Contract Drawings indicate the designed installation for the instruments specified. Where specific installation details are not specified or shown on the Drawings, the American Petroleum Institute (API) Recommended Practice 550 shall be followed as applicable.

E. All work shall be executed in full accordance with codes and local rulings. Should any work be performed contrary to said rulings, ordinances and regulations, the General Contractor shall bear full responsibility for such violations and assume all costs arising therefrom.

F. All equipment used in areas designated as hazardous shall be designed for the Class, Group, and Division as required on the Electrical Drawings for the locations. All work shall be in strict accordance with codes and local rulings. Should any work be performed contrary to said rulings, ordinances and regulations, the Supplier shall bear full responsibility for such violations and assume all costs arising therefrom.

G. Unless specifically shown in the Contract Drawings, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands as detailed on the installation detail drawings or an Engineer approved equal mounting rack or stand. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, valve manifolds for calibration, testing, and blow down service shall also be provided. For slurries, chemical or corrosive fluids, inline diaphragm seals shall be provided.

H. All piping to and from field instrumentation shall be provided with necessary unions, test tees, couplings, adapters, and shut off valves.

I. Field instruments that require power supplies shall be provided with local electrical shutoffs and fuses as required.

J. Brackets and hangers required for equipment mounting shall be provided and shall be installed in a workmanlike manner and not interfere with any other equipment.

K. The PCSI shall investigate each space in the building through which equipment must pass to reach its final location. If necessary, the PCSI shall be required to ship material in sections sized to permit passing through restricted areas in the building. The PCSI shall

also investigate and make any field modifications to the allocated space for each cabinet, enclosure, and panel to assure proper space and access (front, rear, and side).

L. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded at the source end as directed by the manufacturer of the instrumentation equipment. In no case shall there be more than one ground point for each shield.

M. Lifting rings shall be removed from cabinets/assemblies. Hole plugs the same color as the cabinet shall be provided for the holes.

N. The PCSI, acting through the General Contractor, shall coordinate the installation, the placing and location of system components, and their connections to the process equipment panels, cabinets and devices, subject to the Engineer's approval. The PCSI shall be responsible for ensuring that all field wiring for power and signal circuits is done correctly in accordance with best industry practice and provide for all necessary system grounding to ensure a satisfactory functioning installation. The General Contractor hereunder shall schedule and coordinate his work under this Section with that of the electrical work specified under applicable Sections of Division 16.

O. The PCSI shall provide service by the PLC service representative to verify that the entire PLC system is installed per the manufacturer's requirements. The PCSI shall supply certified copies of all the tests/field reports supplied by the PLC service representative to the Owner for their records.

P. The PCSI shall provide service by a factory-trained representative to verify that the entire local area network (LAN) is installed per the manufacturer’s requirements. The PCSI shall include in his bid the cost of the factory trained representative to inspect all LAN terminations and the cost of testing the LAN to verify that it is installed and operating correctly (e.g., data being transferred from node to node, no excessive timeouts, minimal collisions, etc.) The PCSI shall provide certified copies of all tests and legible copies of all field reports generated by the factory-trained representative to the Owner for their records.

3.02 TESTS (GENERAL)

A. The PCSI shall test all equipment at the factory prior to shipment. Unless otherwise specified in the individual specification sections, all equipment provided by the PCSI shall be tested at the factory as a single fully integrated system.

B. As a minimum, the testing shall include the following:

1. Unwitnessed Factory Test (UFT)

2. Functional Demonstration Test (FDT)

C. Each test shall be in the cause and effect format. The person conducting the test shall initiate an input (cause) and, upon the system's or subsystem's producing the correct result (effect), the specific test requirement shall be satisfied.

D. All tests shall be conducted in accordance with prior Engineer approved procedures, forms, and checklists. Each specific test shall be described and followed by a section for sign off by the appropriate party after its satisfactory completion.

E. Copies of these sign off test procedures, forms, and checklists will constitute the required test documentation.

F. Provide all special testing materials and equipment. Whenever possible, perform tests using actual process variables, equipment, and data. When it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation. Define these simulation techniques in the test procedures.

G. The General Contractor shall require the PCSI to coordinate all testing with the Engineer, all affected Subcontractors, and the Owner.

H. The Engineer reserves the right to test or retest all specified functions whether or not explicitly stated in the prior approved Test Procedures.

I. The Engineer's decision shall be final regarding the acceptability and completeness of all testing.

J. No equipment shall be shipped until the Engineer has received all test results and approved the system.

K. The PCSI shall furnish servicemen and all special calibration and test equipment to perform the field tests.

L. Correction of Deficiencies

1. All deficiencies in workmanship and/or items not meeting specified testing requirements shall be corrected to meet specification requirements at no additional cost to the Owner.

2. Testing, as specified herein, shall be repeated after correction of deficiencies is made until the specified requirements are met. This work shall be performed at no additional cost to the Owner.

3.03 UNWITNESSED FACTORY TESTS (UFT)

A. The entire system, except primary elements, final control elements, and field mounted transmitters, shall be interconnected and tested to ensure the system operates as specified. All analog and discrete input/output points not interconnected at this time shall be simulated to ensure proper operation of all alarms, monitoring devices/functions, and control devices/functions. All process control strategies shall be simulated to ensure proper operation according to approved shop drawing.

B. All panels and assemblies shall be inspected and tested to verify that they are in conformance with related submittals, specifications, and Contract Drawings.

C. During the tests all digital system hardware and software shall have operated continuously for five days without a failure to verify the system is capable of continuous operation. The unwitnessed test results shall be submitted to the Engineer for approval prior to the start of the Witnessed Factory Test (WFT).

3.04 FUNCTIONAL DEMONSTRATION TEST (FDT)

A. Prior to startup, the entire installed instrument and control system shall be certified that it is ready for operation. All preliminary testing, inspection, and calibration shall be complete. The FDT will be a test by the PCSI.

B. Once the facility has been started up and is operating, a witnessed FDT shall be performed on the complete system to demonstrate that it is operating and in compliance with these Specifications. Each specified function shall be demonstrated on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis.

C. Loop-specific and non-loop-specific tests shall be the same as specified under WFT except that the entire installed system shall be tested and all functionality demonstrated.

D. Updated versions of the documentation specified to be provided during the factory tests shall be made available to the Engineer at the job-site both before and during the tests. In addition, one copy of all O&M Manuals shall be made available to the Engineer at the job-site both before and during testing.

E. The daily schedule specified to be followed during the factory tests shall also be followed during the FDT.

F. The system shall operate for 100 continuous hours without failure before this test shall be considered successful.

G. Demonstrate communication failure and recovery

H. Demonstrate total power failure and recovery. NOTE: The UPS shall be removed for this test.

I. Demonstrate a catastrophic failure and recovery of a workstation and a RTU (PLC).

J. Demonstrate procedure for backing up the workstation, and RTU (PLC); reload using a backup; and completely restore a workstation and RTU (PLC) from a backup.

3.05 TRAINING

A. General

1. The cost of training programs for the Owner's personnel shall be included in the Contract price. Where practical, the training and instruction shall be directly related to the system being supplied. The training shall be provided based on time and not courses to allow the Owner the flexibility to utilize the training time at his discretion.

2. Training shall be conducted at the Owner's facilities.

3. All Technicians, Operators, Engineers, and Managers of the Facility shall require training on the Process Control System (PCS). The training courses shall address operation, maintenance, and troubleshooting of the system provided. The courses shall be designed specifically for the type of personnel attending, such as Operators, Engineers, etc.

4. All training schedules shall be coordinated with, and at the convenience of, the Owner. Shift training may be required to correspond to the Owner's working schedule.

5. Provide detailed training manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

6. The trainer shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, all training materials shall be delivered to Owner.

END OF SECTION

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Guide Specifications Instructions:
Edit these specifications to tailor to Project, closely coordinating with City-assigned Project Manager. Insert Project Name and Number in headers. Insert Revision Date and Design Consultant's Firm Name, which edited the Section, in footers. Note that headers and footers are mirrored and must be edited separately on even and odd pages. Do not change the base date of this Section in the footer. Specifier to edit Part 3 to provide a site specific control function for any combination of constant speed pumps (2, 3, 4, 5,and 6), dry weather/wet weather (2D/3W, 2D/4W), or Variable Speed Drive (VFD) pumps. Specifier shall evaluate the location of the lift station and modify specifications and drawings for applicable on-site or remote lift station control communication system.

Section 13440

PUMP STATION CONTROL SYSTEM

PART 1 G E N E R A L

1.01 SECTION INCLUDES

A. Programmable logic controller (PLC), remote input/output (I/O) units, Human Machine Interface (HMI), and programmer.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA).

1. NEMA ICS 1 - General Standards for Industrial Control and Systems.

2. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.

3. NEMA ICS 3 - Industrial Systems.

4. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

5. NEMA ST 1 - Standard for Specialty Transformers (Except General Purpose Type).

B. Instrument Society of America (ISA).

C. Underwriters Laboratories, Inc. (UL).

D. Factory Mutual (FM).

E. Institute of Electrical and Electronic Engineers (IEEE).

F. National Fire Protection Association (NFPA). ANSI/NFPA 70 - National Electrical Code (NEC).

G. Joint Industrial Council (JIC).

H. American National Standards Institute (ANSI).

1.03 SUBMITTALS

A. Submit product data, shop drawings and samples (if samples are requested by the City Engineer) under provisions of Section 01330 - Submittal Procedures.

1. Submit in complete packages grouped to permit review of related items as outlined in these specifications.

2. Bind submittals in three-ring binders with complete indexing and tab dividers. Completely tag and label equipment information to correspond with Drawings.

3. Review of Submittals will be for conformance to Contract Documents and for application to specified functions.

B. Product Data: Submit descriptive product literature including manufacturer's specifications for each component specified.

C. Shop Drawings: Indicate layout and mounting of completed assemblies and systems, interconnecting piping and cabling, dimensions, weights, external power and communication connections and programming information.

1. Panel, Console and Cabinet Information.

a. Layout drawings, including the following:

1) Front, rear, end and plan views to scale.

2) Dimensional information.

3) Tag numbers and functional names of components mounted in and on panels, consoles or cabinets.

4) Product information on panel components.

5) Nameplate locations and legends, including text, letter sizes and colors to be used.

6) Location of anchoring connections and holes.

7) Location of external wiring and piping connections.

8) Mounting and installation details.

9) Proposed layouts and sizes of graphic display panels.

b. Wiring and piping diagrams, including the following:

1) Name of panel, console or cabinet.

2) Wiring sizes and types.

3) Piping and tubing sizes and types.

4) Terminal strip numbers.

5) Color coding for each wire and color coding legend.

6) Functional name and manufacturer's designation of components to which wiring and piping are connected.

c. Electrical control schematics in accordance with JIC standards.

d. Plan showing equipment layout in each area.

2. Field Wiring and Piping/Tubing Diagrams

a. Wiring and piping/tubing sizes and types.

b. Terminal strip, device terminal and wire numbers.

c. Color coding.

d. Designation of conduits in which wiring is to be located.

e. Location, functional name and manufacturer's designation of items to which wiring or piping are connected.

f. Point-to-point wiring diagrams identifying every termination point and connection.

3. Instrumentation Diagrams

a. Prepare instrument loop diagrams for analog and digital

displays, and control and I/O loop diagrams, using ISA standard symbols in accordance with ISA Standard S5.4. Drawings shall follow the format and include the following:

1) Instrument tag numbers.

2) Functional name, manufacturer's name, product name and model or catalog number of each item.

3) Location of each item.

b. Submit loop diagrams, wiring diagrams, PLC and control schematics on DVD, formatted as AutoCAD files using the latest release of AutoCAD current and available on bid date, or any subsequent version as well as PDF format. Identify diagrams, schematics and other files with computer-printed labels affixed to each diskette. Leave at least 200,000 bytes free space available on each DVD.

c. In addition, submit such diagrams and schematics laser-printed on 8.5-inch x 11-inch paper. Use lettering and numerals of at least 1/16-inch nominal height.

4. Programmable Controller System I/O Loop Wiring Diagrams

a. Prepare drawings on a module-by-module basis. Include the following information:

1) Rack numbers, module types and slot numbers, module terminal point numbers, and location and identification of intermediate panel and field terminal block and strip numbers to which I/O wiring and power supply wiring is connected. Identify power supply circuit numbers and ratings.

2) Wiring sizes, types, wire numbers and color coding.

3) Designation of conduits in which field I/O wiring is to be run.

4) Locations, functional names, tag numbers and manufacturer's names and model numbers of panel and field devices and instruments to which I/O wiring is connected. Label wiring and cables at both ends and within junction and terminal boxes. Use sleeve-type plastic wire markers covered with clear heat-

shrink labels, or machine-printed permanent ink heat-shrink labels by Brady or approved equal.

b. For each drawing, submit one reproducible hardcopy and one copy on DVD, formatted as AutoCAD files using the latest release of AutoCAD current and available on bid date, or any subsequent version as well as PDF format. Identify diagrams, schematics and other files with computer-printed labels affixed to each diskette. Leave at least 200,000 bytes free space available on each DVD.

c. In addition, submit such diagrams and schematics laser-printed on 11 x 17 inch paper. Use lettering and numerals of at least 1/16 inch nominal height.

5. System Programming Information

a. At least six weeks prior to substantial completion, submit detailed programming information consisting of ladder logic and proposed program code, complete input, output, relay, register and controller identification labels, memory allocation table, and written description of program operation.

b. Ladder logic diagrams shall contain a written descriptive note for each line of program code describing the function and logic of that line.

c. Submit documents in hard copy and as computer-readable files on DVD. Leave at least 200,000 bytes free space available on each DVD. PLC, HMI, MPR, VFD and all other operational, installation and application related programs required necessary by the City of Houston with the installation shall be submitted in native programming language files.

D. Quality Control Submittals

1. Factory Test Reports: If specified, submit 6 copies.

2. Testing Procedures: Submit testing procedures proposed to verify input, output, loop and register operations, system logic verification, and spare memory capacity. Testing procedures shall detail, as a minimum, verification of required functions as follows:

a. Verification of pump start, pump stop, and well level alarm outputs by simulation of analog signals representing pump level.

b. Verification of each discrete input via external manually-operated switch.

c. Verification of each analog input by connection of external analog indicator in input loop.

d. Verification of each analog output by connection of external analog indicators.

e. Verification of communications system by hardwire connection via modem and wiring to a similar unit. Demonstrate operation and status monitoring of each register specified for external monitoring.

f. Verification of spare memory capacity by hard copy printout of full memory bit map after successfully demonstrating that system logic, inputs, outputs and communications features are fully installed and operational.

g. Test and verify system with external devices required to simulate field connections connected simultaneously for a full system test.

h. Reconnecting external devices to verify portions of the systems at a time is not acceptable.

3. Certificates: Under provisions of Section 01450 - Contractor's Quality Control, submit manufacturers' certificates that equipment and systems meet or exceed specified requirements.

4. Instructions: Submit manufacturer's installation instructions for each component specified.

5. Field Reports: Submit 6 copies of Manufacturer's Installation Inspection, Field Calibration and Field Testing Reports.

6. Site Acceptance:

E. Operations and Maintenance (O&M) Data.

1. Submit operation and maintenance data notebook in accordance with Section 01782 - Operations and Maintenance Data.

2. Information and drawings submitted must reflect the final installed condition. Revise documents requiring updates following testing and

start-up.

3. In addition to the content specified in Section 01782 - Operation and Maintenance Data, provide the following information:

   a. Name, address and telephone number of the control system supplier's local service representative.

   b. Complete list of supplied system hardware parts with full model numbers referred to system part designations, including spare parts and test equipment provided.

   c. Copy of approved submittal information and system shop drawings as specified in Paragraph 1.3, Submittals, with corrections made to reflect actual system as tested, delivered and installed at the site. Provide half-size blackline reproductions of all shop drawings larger than 11 inches x 17 inches.

   d. Complete up-to-date system software documentation.

   e. Original copies of manufacturer's hardware, unprotected software, installation, assembly and operations manuals for the programmable controller and data communication system, single loop and multi-loop controllers and other control system components. In addition to hard copy versions, provide all manuals in PDF format on DVD.

   f. Instructions for PLC replacement adjustment, and preventive maintenance procedures and materials.

   g. Control system description and system operation sequence instructions.

   h. For each major system/subsystem, in separate binders, submit PLC ladder logic programming documentation (fully annotated of each network headers, logical elements, control descriptions), PLC I/O schematics, control and loop diagrams, electrical drawings, system description, operation instructions AutoCAD and PDF format and files on DVD.

F. Project Record Documents

1. Submit record documents under provisions of Section 01785 - Project Record Documents.

2. Revise system shop drawings, software documentation and other submittals to reflect system as installed. Accurately record locations of controller cabinets and input and output devices connected to system. Include interconnection wiring and cabling information and terminal block layouts on rite in the rain all weather writing paper in a suitable drawing pocket installed inside the controller cabinet door.

3. Insert half-size blackline prints of wiring diagrams applicable to each control panel in a clear plastic envelope and store in a suitable print pocket or holder inside each control panel.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer shall be a company specializing in manufacturing products specified in this Section, having proven compatibility with the City's existing facilities and at least 5 years of documented experience. The company shall maintain service facilities within 100 miles of the City of Houston.

B. System Integrator / Panel shop Qualifications: System Integrator / Panel shop shall be a company specializing in installation of products specified in this Section, having proven experience with the City's existing facilities and at least 5 years of documented record. The company shall maintain service facilities within 100 miles of the City of Houston.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site in factory-sealed containers. Store and protect products under provisions of Section 01610 - Basic Product Requirements.

B. Check for damage upon receiving products on site.

C. Store products in a clean, dry area; maintain temperature in accordance with NEMA ICS 1.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Maintain temperature above 32 degrees F and below 104 degrees F during and after installation of products.

B. Maintain area free of dirt and dust during and after installation of products.

C. Provide temporary heating and air conditioning units and equipment required to maintain environmental conditions specified for control and MCC panels.

1.07 MAINTENANCE SERVICE

A. Provide manufacturer's maintenance services for programmable logic controllers for one year from Date of Substantial Completion without additional cost to the City.

PART 2 P R O D U C T S

2.01 PROGRAMMABLE LOGIC CONTROLLER (PLC)

A. PLC CPU

1. Manufacturer and Model: Siemens Industry, S7-1214C
2. Port: Ethernet, RJ45
3. Built-in Discrete I/O: 14 Discrete Inputs (24 VDC), 10 Relay Outputs
4. Built-in Analog I/O: 2 Analog Inputs
5. Power: 24 VDC
6. Expandability: 8 Signal Modules, 1 Signal Board, 3 Communication Modules

B. Discrete Input Expansion Module

1. Manufacturer and Model: Siemens Industry, S7-1221
2. Discrete Inputs: 16
3. Input Type: 24VDC, Current Sourcing/Sinking

C. Relay Output Expansion Module

1. Manufacturer and Model: Siemens Industry, S7-1222
2. Relay Outputs: 16
3. Output Type: 5-30 VDC, 30W / 5-250 VAC, 200W

D. Discrete Input / Output Expansion Module

1. Manufacturer and Model: Siemens Industry, S7-1223
2. Discrete Inputs: 8
3. Input Type: 24VDC, Current Sourcing/Sinking
4. Relay Outputs: 8
5. Output Type: 5-30 VDC, 30W / 5-250 VAC, 200W

E. Analog Input Expansion Module

1. Manufacturer and Model: Siemens Industry, S7-1231
2. Analog Inputs: 4
3. Input Types: 0-20 ma

F. Analog Output Expansion Module

1. Manufacturer and Model: Siemens Industry, S7-1232
2. Analog Outputs: 4
3. Output Types: 0-20 ma

G. Memory Card

1. Manufacturer and Model: Siemens Industry, S7-954
2. Capacity: 4 MB or larger.

H. Communication Interfaces for Remote Lift Station or Plant On-Site Lift Station:

1. Ethernet Interface: Integral to CPU, 10/100 Mbps with automatic speed detection, PLC programming, HMI communications, S7 Communications and Profinet.

2. Profibus DP: Standard baud rates capable up to 12 Mbit/sec, configured in standard PLC programming environment. Supports Profibus DP Slave, and S7 communications.

3. Ethernet Switch Managed Industrial Ethernet Switch to be mounted in control panel and connected to PLCs with Ethernet interface.

I. Ethernet Networking

1. Ethernet Switch - Remote WiMAX Lift Stations

a. Manufacturer and Model: Siemens Industry, X310

b. Design: Industrial, Managed, DIN Rail Mount

c. Copper Ports: Ten (10) RJ45, 10/100 Mbps

d. Fiber Optic Ports: None

e. Configuration Back-up: Include configured C-Plug

J. Ethernet Switch

1. Industrial Ethernet Switch: Managed Industrial Ethernet Switch to be mounted in control panel and connected to PLCs with Ethernet interface.

a. Fiber Optic Networks: SCALANCE X204-2

1) Manufacturer and Model: Siemens X204-2

2) Electrical Ports: Four RJ45, 10/100 Mbps, Connectors latch to housing for strain relief.

3) Optical Ports: Two female ST pairs, 100 Mbps

4) Fiber Topology: Bus, Star, and Ring

5) Power: Redundant 24 VDC

6) Mounting: Standard DIN rail, PLC Rail

7) Diagnostic LEDs: Power, Link Status, Communications

8) Housing: Metal

9) Include C-Plug Configuration Plug

b. Copper-Only Networks: SCALANCE X208

1) Manufacturer and Model: Siemens X208

2) Electrical Ports: Eight RJ45, 10/100 Mbps, Connectors latch to housing for strain relief.

3) Power: Redundant 24 VDC

4) Mounting: Standard DIN rail, PLC Rail

5) Diagnostic LEDs: Power, Link Status, Communications

6) Housing: Metal

7) Include C-Plug Configuration Plug

2. Industrial Ethernet Cable, Copper, for Runs Outside Control Panels

a. Manufacturer and Model: Siemens Industry, 6XV1-840-2AH10

b. Style: Industrial Ethernet Fast Connect (FC) Standard Cable

c. Type: Four-wire, shielded

d. Jacketing: Green PVC Sheath, 6.5 +/- 0.4 mm OD

e. Temperature: -40 to 70 deg. C operating, transport and storage

f. Include Stripping Tool: Siemens Industry, 6GK1-901-1GA00

3. Industrial Ethernet Connectors, Copper

a. Manufacturer and Model: Siemens Industry 6GK1-901-1BB10-2AA0 (straight) or 6GK1-902-1BB20-2AA0 (90-degree)

b. Permissible Cable: Industrial Ethernet FastConnect Cable

c. Installation: Insulation Displacement via simple cable insertion and housing closure

d. Strain relief: Via quarter-turn locking mechanism

e. Housing: Metal with metal spring clip

4. Industrial Ethernet and Profibus Cable, Fiber Optic

a. Manufacturer and Model: Optical Cable Corp)

b. Fibers: 6 multimode fibers minimum, 25% spare pairs minimum, 62.5/125 graded index

c. Type: Tight-Buffered, Riser-Rated, Multi-fiber Breakout-Grade Cable

d. Jacketing: Indoor/outdoor PVC outer jacket, Color-coded subcables protected to permit direct field termination without patch boxes, jumpers, splices, etc.

e. Primary Fiber Buffer: 500 micron acrylate buffer over each optical fiber

f. Secondary Fiber Buffer: 900 micron elastomeric tight buffer over each optical fiber

g. Connectors: ST, Factory-terminated or field-installed and tested

h. Diameter: 9.5 mm (0.37 in)

i. Tensile Load Rating: 270 lbs. long-term, 670 lbs. short-term (installation)

j. Minimum Bend Radius: 3.7” under long-term tensile load, 7.4” under installation load

k. Temperature: -40 to 85 deg. C operating

5. Industrial Ethernet and Profibus Fiber Optic Patch Panel

a. Manufacturer :

1) Panduit

2) Black Box

3) 3M

4) Leviton

5) Corning

b. Design: Metal box with latching door covering two chambers

c. Connectors: Populated 6-packs with ST connectors

d. Mounting: Wall mount

e. Minimum 12 ports and up to 24 ports.

6. Industrial Ethernet, Wireless Access Point

a. Manufacturer and Model: Siemens Industry SCALANCE W788-1PRO or W788-2PRO

b. Radio Networks: Single (-1PRO) or Dual (-2PRO) depending on project requirements

c. WLAN Standards: IEEE 802.11b/g, IEEE 802.11a/h

d. Data Security: WEP, WPA2/IEEE 802.11i with AES and TKIP, EAP-TLS, EAP, TTLS, EAP-PEAP, EAP-MD5, EAP-MSChapv2, MAC Filter, Admin Password

e. Degree of Protection: IP65

f. Ethernet Interface: IE Hybrid Socket (IP65); RJ45 Connection

g. External Antenna Connections: Two (or four for Dual) R-SMA with included Omnidirectional Direct-Mounted Removable Antennas

h. External Antennas: As needed, Siemens ANT-79X selected for necessary Antenna Gain at installed frequency

i. Lightning Protection: Include LP798-1PRO Lightning Protector on cable to external antenna

j. Power: 24VDC, Redundant

k. Operating Temperature: -20 to 60 deg C

l. Include C-Plug Configuration Plug

7. Industrial Ethernet, Wireless Client Module

a. Manufacturer and Model: Siemens Industry SCALANCE W740-1PRO

b. WLAN Standards: IEEE 802.11b/g, IEEE 802.11a/h

c. Data Security: WEP, WPA2/IEEE 802.11i with AES and TKIP, EAP-TLS, EAP, TTLS, EAP-PEAP, EAP-MD5, EAP-MSChapv2, MAC Filter, Admin Password

d. Degree of Protection: IP65

e. Ethernet Interface: IE Hybrid Socket (IP65); RJ45 Connection

f. External Antenna Connections: Two (or four for Dual) R-SMA with included Omnidirectional Direct-Mounted Removable Antennas

g. External Antennas: As needed, Siemens ANT-79X selected for necessary Antenna Gain at installed frequency

h. Lightning Protection: Include LP798-1PRO Lightning Protector on cable to external antenna

i. Power: 24VDC, Redundant

j. Operating Temperature: -20 to 60 deg C

k. Include C-Plug Configuration Plug

K. Programming, Software and Programming Equipment

1. Configure system and program for operation as specified in this Section.

2. System Software: Siemens Step 7 software will be loaned by City for utilization by contractor on this project. Contractor to supply any other software or interfaces and cables needed to support equipment supplied on this project.

3. Control Program: A generic lift Station PLC Control Program will be provided by Wastewater Operations. Contractor shall provide necessary programming modifications and enter the required variable parameters to provide a complete functional and integrated system. Contractor shall customize the generic software to meet site-specific conditions. The system shall be fully tested to be operational prior to substantial completion.

4. Control Program Data Sheet: Contractor shall complete and submit Lift Station Data Sheet to Control Program Librarian designated by City of Houston. System I/O list shall be submitted with Data Sheet to the City of Houston two weeks prior to the 7-day test where communication can be verified by the Control Center. (Refer to Attachment 13440 A and B)

5. Programmer (City of Houston Wastewater Plant applications only): HP ZBook Mobile Workstation or equivalent current model, new, submitted in the original package including manuals having at least the following features as minimum:

a. Operating system: Genuine Windows 7 Professional 64

b. Processor: Intel Core i7-4700MQ Processor (2.4 GHz, 4MB L3 cache)

c. Memory: 8GB 1600 MHz DDR3L SDRAM.

d. Hard drive: 750 GB 7200 rpm SATA, 32GB MSATA SSD

e. Optical drive: DVD-ROM; DVD+-RW SuperMulti DL LightScribe; Blue-ray R/RE DVD+/-RW SuperMulti DL

f. Display: 15.6 diagonal LED-backlight HD anti-glare

g. Graphics: NVDIA Quadro FX 1800M graphics with 1 GB dedicated GDDR5 video memory.

h. I/O Ports: External – 3USB 2.0, 2USB 3.0, 1eSATA, 1 external VGA monitor, 1 Display Port, 1 1394a, 1 stereo microphone in, 1 stereo headphone/line-out, 1 AC power, 1 RJ-11, 1 RJ-45, 1 docking connector, 1 secondary battery connector.

i. Slots: 1 Express Card/54, 1 Smart Card Reader, 1 Secure Digital.

j. Network interface: Integrated Intel Gigabit Network Connection (10/100/1000 NIC).

k. Wireless: HP Mobile Broad (powered by Gobi) with GPS; Intel Centrino Ultimate-N 6300 (3x3) 802.11 a/b/g/n; HP Integrated Module with Bluetooth 2.1 Wireless Technology.

l. Energy Efficiency: ENERGY STAR

m. Battery: HP Long Life 8-cell (68 WHr) Li-Ion

n. Power supply: External 150-watt Smart AC adapter; External 120-Watt Smart AC adapter; External 90-watt Smart AC adapter; HP Fast Charge

o. Security management: Standard – Integrated Smart Card Reader, HP ProtectTools, TPM Embedded Security Chip 1.2, Enhanced Pre-Book Security, HP Spare Key (require initial user setup), HP Disk Sanitizer, Enhanced Drive Lock, drive Encryption for HP ProtectTools, Credential Manager for HP ProtectTools, File Sanitizer for HP Protect Tools

p. Warranty: HP services offers limited 3-year standard parts and labor onsite, next business day warranty, and toll-free 7 x 24 hardware technical phone support; 1-year limited warranty on primary battery. On-site service and warranty upgrades are also available.

q. Preinstalled Microsoft Windows in latest versions currently available that are compatible with HMI software.

r. Programming cable and adapter for PLC programming.

s. Compaq Workstation carrying case (overall size 18"x13"x5").

L. Provide at least 25% of each PLC module furnished as spare parts. Minimum spare parts will include the following for each type furnished:

1. One discrete input module, of each type.

2. One discrete output module, of each type.

3. One analog input module, of each type.

4. One analog output module, of each type.

5. One PLC power supply, of each type.

6. One PLC CPU.

7. One Ethernet Switch where applicable

M. Connect PLC inputs/outputs including analog inputs through snap-on isolated fused terminal blocks.

N. Separate the AC and control signals from DC and loop signals by at least 6 inches. Provide a barrier between AC and DC within the raceways.

2.02 LOCAL WORK STATION

A. General

1. Manufacturer and Model: Siemens Industry, TP900-Comfort touch panel.

2. Display: 9.0” 800 x 480 TFT LCD Touch Panel.

3. Keyboard: Numeric / Alphabetic Entry.

4. Memory: 12 MB.

5. Memory Card: Two MMC/SD combination slot

6. Operating System: Windows CE

7. Ports: One RS 422/485, USB, Ethernet RJ-45

8. Power: 24 VDC.

9. Certifications: IP65 / NEMA 4 / FM Class I, Division 2 when mounted.

10. Configuration: A generic Lift Station HMI Configuration will be provided by Wastewater Operations. Contractor shall provide necessary modifications and enter the required variable parameters to provide a complete functional and integrated system. Contractor shall customize the generic software to meet site-specific conditions. The system shall be fully tested to be operational prior to substantial completion.

11. Configuration Software: Configuration software not including cable will be loaned by City for utilization by contractor on this project. Contractor to supply any other software needed to support equipment supplied on this project.

12. Provide necessary cables and connectors to communicate between Operator Panel and PLC processor. Following is a list of sample displays to be provided:

    a. Station name, facility number, and address.

    b. Screen Listing.

    c. Status and alarm display for each pump

    d. PLC I/O health Status.

    e. Wet Well Level Set points.

    f. Wet Well Level Readings.

    g. Seven-day level trends

    h. One-day level trend

13. Supply configuration software, latest version, and download cable.

14. Note: Pump Information and necessary status points shall be configured as needed. All configurations shall be performed by the contractor.

PART 3 E X E C U T I O N

The required system shall activate ASD the constant speed feature for 1,2, 3, 4, 5, and 6. Only 4 ASD units are installed in this phase, however in the future the pump ASDs will be changed and an addition 2 ASD will be provided.

3.01 SYSTEM DESCRIPTION

A. Level Measurement System: Equip the pump station with one well level measurement system and a float back-up the submersible transmitter and associated cable and installation mounting hardware to provide a 4-20 mA loop signal proportional to well level and recorder as indicated on the Drawings.

B. Installation: Fabricate and install stilling well for each submersible transmitter.

1. Support Hardware: Provide mounting stainless steel hardware as required for supporting 6” Schedule 80 PVC inside support to guide each transmitter cable and cord.

2. Support cable: 1/8 inch stainless steel 316 cable to support and hold transmitter.

3. Access manhole: Provide access manhole where the transmitter can easily be removed, installed, and maintained.

C. Primary Pump Constant Speed for ASD or VFD units for Pumps 1, 2, 3, 4, 5, and 6 pumps.

1. PLC shall monitor the primary level measurement system and control a PLC output to energize a relay to start / stop pumps at preselected well levels..

2. The primary control system shall monitor a NO contact which closes when the pump is running and shall totalize pump running time and store last 100 entries.

3. The primary control system shall provide first-on first-off alternate sequencing of pump starts.

4. The primary control system shall provide a numerical sequencer to sequence available pumps.

5. Stagger start times by 10 seconds between pump lead/lag stages to prevent pumps starting at the same time on a power failure or system

reset. If a response to a pump signal to run command is not confirmed within 20 seconds (through auxiliary feedback), PLC logic shall remove that pump from service and a pump sequence, but transfer the command signal to the next available pump in the same sequence.

6. Phase failure, overload, high temperature, and seal leak alarms shall provide a common alarm and cause a pump to stop in either Primary or Back-up mode. Alarm conditions shall keep the pump out of service and shall only be reset through the control panel push-button or SCADA. When power failure condition, control shall automatically operate pumps in primary or back up mode when power is restored without local or remote alarm reset.

7. If a period of 8 hours expires with no pump sequence rotation (one pump running and more than one pump available), the control shall stop the lead pump and rotate the sequence.

8. Provide remote start, stop, and alarm reset capabilities.

9. Low level alarm shall cut all pumps off.

10. The primary control system shall test and select the functioning transmitter to control pumps in the primary mode (PLC).

D. Back-up Pump Control

1. The back-up pump control systems is accomplished via the high level float switch activating a system timer to RUN all the Pumps for a time period. A local high level alarm and PLC input is activated.

E. Pump Status and Alarm Monitoring: PLC shall monitor NO contacts which close to indicate the following:

1. Pump status for each pump.

2. Alarm for each pump.

3. Normal/emergency power source

4. Station undervoltage/phase failure alarm.

5. Intrusion alarm (control building or control panel).

6. Wet pit high alarm when applicable

7. Operation mode selector switch PLC/backup

F. Pump Controls: PLC shall provide an NO contact which closes and provides 120VAC to drive the following discrete pump control outputs:

1. Start/stop for each pump.

2. Common alarm reset.

3. High/low level alarms.

G. Pump Station Monitoring: PLC shall monitor the wet well level transmitter to indicate pump station level readings, start/stop set points, high/low and level alarms.

H. Communications: PLC shall be capable of full two-way communications with the City of Houston Plant Control Room to the Central Control facility. Communications shall have the capability to transmit all station and pump status and alarms, well levels, PLC status and additional information indicated in the Drawings, and shall receive pump start/stop set points, alarm set points and miscellaneous data via City of Houston SCADA software package and protocol. Provide necessary hardware and software required to implement the communications system as part of pump station control system work. Programming and modifications required at the City of Houston Central Control facility will be performed by the City of Houston. Contractor shall be responsible for coordinating and performing the communication testing verification of I/O.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions and Drawings. Provide sufficient clearance for calibration and maintenance access.

B. Do not install products until major construction is complete and building interior is enclosed and heated.

C. Connect input and output devices as shown on Drawings.

D. Provide complete programming, testing and verification of the programmable controller and associated inputs and outputs, including work required to interface with the existing City of Houston system.

3.03 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 01755 - Starting Systems.

3.04 DEMONSTRATION

A. Provide systems demonstration under provisions of Section 01770 - Closeout Procedures.

B. Demonstrate operation and programming of controller. Provide 2 sessions of 4 hours of instruction each for 4 persons, to be conducted at project site with manufacturer's representative.

C. System demonstration shall include the following:

1. Complete verification of field wiring.

2. Complete verification of system software.

3. Demonstration of functionality of each discrete input and output by simulation of actual field device action.

4. Demonstration of functionality of each analog input and output by actual variations in the process variable (e.g. well level, etc.).

5. Complete demonstration of each alarm by simulation of actual field device action.

6. Complete demonstration and verification (status/alarm points) of 2-way communication with City of Houston Central Monitoring Facility.

3.05 TRAINING

A. Provide engineering and programming schools preferably at the Houston offices of the PLC manufacturer or distributor or at the manufacturer's factory, as specified below. This training shall be performed by fully-qualified and manufacturer-certified training personnel who can clearly illustrate experience in teaching previous courses. Obtain approval from the Owner’s representative for training facility and course outline before scheduling training.

B. If such training is provided somewhere other than Houston, then the system supplier shall provide coach airfares, hotel expenses, rental cars, and meal allowances per City of Houston traveling and lodging requirements for selected City personnel for the duration of the schools.

C. Schedule classes at the City of Houston's convenience. The supplier should not assume that the City's personnel will attend these courses in a continuous and sequential manner. When training is submitted in voucher form, it shall be valid for a minimum of 1 year at no extra cost to the City.

D. Training shall consist of the following as a minimum:

1. PLC basic/advanced programming/maintenance (5 days): Four people

END OF SECTION

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THE FOLLOWING ITEMS SHOULD BE CHECKED FOR COORDINATION DURING DESIGN:

A. Coordinate this specification with other specifications including the following related Sections:

Section 01450 - Contractor's Quality Control
Section 01610 - Basic Product Requirements
Section 01630 - Product Substitution Procedures
Section 01755 - Starting Systems
Section 01770 - Closeout Procedures
Section 01782 - Operations and Maintenance Data
Section 01785 - Project Record Documents
Section 13441 - Software Engineer
Section 13446 - Primary Instrumentation Devices
Section 13471 - Control Cabinet Enclosures
Section 16195 - Wiring and Conduit Identification
Section 16910 – Manual Transfer Switch
Section 16950 – Uninterruptible Power Supply

END OF NOTES

Section 13441

SCADA SOFTWARE ENGINEERING SECURITY AND QUALITY REQUIREMENTS

PART 1: GENERAL

1.01 PURPOSE

A. The Wastewater Operations Automation and Electrical Support Service Group maintains this document for the communication of the requirements of the SCADA software used for the control and monitoring of the wastewater facilities. These requirements are intended to address three related areas: 1) SCADA Homeland Security Requirements, 2) Texas Engineering Practice Act, 3) COH Wastewater SCADA system quality requirements:

1. According to the National Strategy for Homeland Security wastewater treatment facilities are part of the nation's critical infrastructure and the government agencies that are responsible shall take specific steps to improve SCADA security.

   a. Government agencies are required to "Establish policies to minimize the likelihood that organizational personnel will inadvertently disclose sensitive information regarding SCADA system design, operations, or security controls" and "Release data related to the SCADA network only on a strict, need-to-know basis, and only to persons/entities explicitly authorized to receive such information".

   b. In compliance with these Homeland Security requirements all SCADA related information is restricted to authorized personnel.

2. In compliance with Texas Engineering Practice Act (Article 3271a) and the recognition that SCADA software is an integral part of the electrical control of the wastewater facilities and is therefore within the jurisdiction of the act:

   a. All SCADA software related work shall be performed by a licensed engineering firm meeting the qualifications as specified in these requirements and referred to within as the Software Engineer (SE). The software produced for the project shall be stamped by SE in accordance with (Article 3271a §137.33 Sealing Procedures for engineering software).

3. Additionally, these requirements are to refine and perpetuate software engineering and software quality standards that will benefit the Wastewater Operation Branch in the areas of facility operations, maintenance, and facility construction projects:

   a. The requirements are intended to benefit facility operations through encouraging SCADA standards of consistency in facility functionality and operation, improved process visibility, improved efficiency and control, lower operating costs and

reduced potential permit violations. The SCADA standardization also addresses improved technical support and ease of maintenance.

b. These requirements specify SCADA related issues in construction, deliverables and qualifications that will help ensure the availability and quality of SCADA system integration.

c. SCADA related software integration activities have been identified as a key point of quality control for construction projects. The SE shall subcontract directly to the general contractor and shall perform an independent assessment of the SCADA related work of the other subcontractors and equipment suppliers to ensure complete system and software integration within the facility per the construction specification and wastewater SCADA design guidelines.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

PART 2: PRODUCTS

2.01 SCOPE

A. The requirements defined in this document apply to wastewater facility SCADA software including system control, monitoring and integration. The scope includes new and existing facility construction projects where new SCADA software is required or where the existing SCADA software is modified.

B. SCADA software activities shall be performed only by the pre-approved SE and include: PLC programming, HMI configuration and graphics development, historical logging software application and report generation, network configuration and programming.

C. Manufactured packaged subsystems with pre-engineered software may be specifically excluded if specified in that subsystem equipment specification, that the system shall be shipped with the software as a fully functional unit. The system PLC and HMI hardware and software application shall meet the requirements for SCADA integration and software documentation. The packaged system provider shall deliver all software to SE as soon as possible for the purpose of review and integration.

D. These requirements apply to all SCADA security related activities including configuration of servers, workstations and network equipment.

PART 3: EXECUTION

3.01 SOFTWARE ENGINEERING REQUIREMENTS

A. The SE shall perform the software engineering functions as required within the scope section meeting the requirements within.

B. The SE shall use the wastewater standards for SCADA software engineering and Homeland Security in all work performed.

1. The SE shall identify and communicate omissions and required modifications to these standards.

2. Details on these standards are restricted to authorized personnel only according to the Homeland Security requirements and are not included in these requirements. The pre-approved SE is authorized for access to these standards.

C. The SE shall provide the SCADA related submittals as defined in the submittals section.

D. The SE shall perform the work required to complete the required SCADA software submittals.

E. The SE shall review and report on the SCADA related submittals of the project subcontractors and equipment providers.

F. The SE shall assist the project team including; the engineer, the wastewater operations and equipment suppliers with the SCADA integration issues.

G. The SE shall attend project meetings as required by the project team.

H. The SE shall assist the project team with functional test of the system.

1. This may include providing project related process data from the SCADA system.

PART 4: MODIFICATIONS

4.01 SUBMITTALS

A. Within 30 days of the notice to proceed the SE shall submit a letter of SE qualifications specifically addressing each item of qualification as defined in these requirements.

B. Include the SE professional engineering firm licensed number and date of issuance.

C. Include a statement addressing the awareness of the Homeland Security concerns and intention to restrict the dissemination of security sensitive SCADA network information to those who are authorized by the COH and require the information in the support of this project.

D. Within 90 days of the notice to proceed the SE will submit the Software Engineering Manual (Preliminary Report).

E. Include the software conventions for the use in the HMI development.

F. Include diagrams and schedules for all network devices associated with the process control and monitoring for the facility/facilities.

G. Include the interfaces for the City SCADA network.

H. Identify every network component (new and existing).

I. The Software Engineering Manual will be updated for the final O&M.

J. The SE will submit letters of software and network integration compatibility to be included in all the control related submittals.

K. Included but not limited to: PLCs, network devices, computers, HMI devices.

L. Include deviations from City standards and the construction specifications for electrical control drawings and tag naming conventions.

M. Include deviations from the submitted Software Engineering Preliminary Report.

N. Include the manufacturer supplied package systems with control panels.

O. The SE shall distribute monthly a Software Engineering Integration Schedule highlighting software and system integration progress and issues.

4.02 FACTORY DEMONSTRATION TEST CONFIRMATION REPORT

A. After the required factory demonstration test the SE shall submit a report confirming the related software and network compatibility.

4.03 FIELD ACCEPTANCE FUNCTIONAL TEST

A. Shall be completed prior to performance and reliability testing.

B. Field Acceptance Functional Test Submittals shall include:

1. Field Acceptance Functional Test Plan Submittal.

2. Description of plan for testing field devices.

3. Description of plan for function test and system integration of each subsystem.

4. Field Acceptance Functional Test Schedule shall be submitted after the acceptance of the test plan submittal.

5. Field Acceptance Functional Test plan completion report shall be submitted.

4.04 UPDATED SOFTWARE ENGINEERING MANUAL (FINAL VERSION)

A. Update and submit a singled CD with all related SCADA software.

B. Control and network components.

C. Inventory of software components.

D. Network device configuration documentation.

E. Software Engineering documentation.

F. PLC and HMI software shall be documented using the product development tool.

G. Software shall be stamped as required in Texas Engineering Practice Act (Article 3271a §137.33 Sealing Procedures) with the date, the engineers name, the PE designation with license number.

H. The SE will collect and submit all software and network device configuration programs and data developed for the project.

PART 5: SOFTWARE ENGINEER (SE) QUALIFICATIONS

A. The Wastewater Operations Automation and Electrical Support Services group has set forth these qualifications for performing all SCADA related software activities for the wastewater facilities as defined in these requirements.

B. The SE shall be pre-approved by Automation and Electrical Support Services section for Wastewater Operations no later than seven (7) days prior to the project bid opening date for construction projects.

5.01 SPECIFIC QUALIFICATIONS FOR PRE-APPROVED SE

A. The SE shall be a Texas Registered Professional Engineering firm with a minimum of five (5) years of licensed history with the software engineering of the control systems for advanced wastewater treatment processes.

B. The SE shall be experienced with the software application development packages which are used as standards for Wastewater Operations including a minimum five (5) years of software engineering experience with Wonderware Archestra and G.E. IFIX HMI application development packages and Siemens PLCs.

C. The SE shall demonstrate a minimum of five (5) years of continuous Cisco Advanced Security expertise. This ensures the SE has the required expertise to configure, secure and maintain the SCADA system network for applicable projects (excluding stand-alone control system at the lift stations and small plants where only a single PLC is installed).

D. The SE shall have errors and omissions insurance with coverage in the amount of $1,000,000.00 (aggregate).

E. The SE shall have an existing office, within the City of Houston, and shall maintain that office for the duration of the warranty and extended software service requirement.

F. To ensure effectiveness and objectivity in the review and reporting of SCADA related integration issues, the SE shall be an independent entity and provide only software engineering services for the construction projects. Additional scope of automation and electrical services may be provided as required by the owner. The services may include, but not limited to network diagram development, efficiency and optimization program and application implementation, data dictionary design guideline development.

END OF SECTION

Section 13446

PRIMARY INSTRUMENTATION DEVICES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Telephone modems, pump controllers, submersible transmitters, level recorder, power meter, control power transformers, phase/voltage monitor relay, terminal blocks, surge protections, and accessories for use with lift station instrumentation.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES AND STANDARDS

A. NEMA ICS 1 - General Standards for Industrial Controls and Systems.

B. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.

C. NEMA ICS 3 - Industrial Systems.

D. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

E. NFPA 70 - National Electrical Code (NEC).

F. Underwriters Laboratories, Inc. (UL).

G. ANSI B40.1 - Gauges, Pressure Indicating Dial Type Elastic Element.

1.04 SUBMITTALS

A. Comply with Section 01330 - Submittal Procedures.

B. Submit shop drawings indicating layout of completed assemblies, interconnecting cabling, dimensions, weights and external power requirements.

C. Submit product data for each component specified.

D. Submit manufacturer's certificate that all equipment meets or exceeds specified requirements.

E. Submit manufacturer's installation instructions.

1.05 PROJECT RECORD DOCUMENTS

A. Submit record documents under provisions of Section 01770 - Closeout Procedures.

B. Accurately record actual locations of controller cabinets and input and output devices connected to system. Include interconnection piping, wiring and cabling information, and terminal block layouts in controller cabinets.

C. During drawing submittal phase, submit detailed programming information consisting of ladder logic and line code of proposed program, and complete input, output, relay, register and controller identification labels.

D. Submit factory testing procedures proposed to verify input, output, loop and register operations, system logic verification, and spare memory capacity.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit operation in accordance with Section 01782 - Operations and Maintenance Data.

1.07 QUALIFICATIONS

A. Manufacturer: A company specializing in manufacturing the products specified in this Section having at least 3 years documented experience maintaining service facilities within 100 miles of project and having proven compatibility with existing City wastewater facilities. Like devices shall be of the same Manufacturer.

1.08 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70 (NEC).

B. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for the purpose specified and shown; install in accordance with UL requirements.

1.09 DELIVERY, STORAGE AND HANDLING

A. Deliver products in factory-sealed containers. Store, handle and protect products under provisions of Section 01610 - Basic Product Requirements.

B. Upon delivery, inspect products for damage.

C. Store products in clean, dry area; maintain temperature in compliance with NEMA ICS 1.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Maintain temperature above 32 degrees F and below 104 degrees F during and after installation of products.

B. Maintain area free of dirt and dust during and after installation of products.

PART 2: PRODUCTS

2.01 SUBMERSIBLE PRESSURE TRANSMITTERS

A. Manufacturer:

1. Endress and Hauser: Model FMK165-AKA 10C .

2. Blue Ribbon: Model Birdcage GP: 50 (15, 30 psi)

3. AMETEK: Model 575P

4. Dwyer: PPBL2 series

B. Description: Solid-state two-wire submersible electronic differential pressure transmitter with 4-20 mA output proportional to input pressure.

C. Range: 0-5

D. 0 feet range, or as required by wet well depth, with +/- 0.3 % accuracy and 0.5% max temperature across calibrated span.

E. Power: Loop-powered, 24 VDC

F. Spare Unit: Provide a spare unit in addition to the unit installed.

G. Transmitters to be calibrated to match the chart recorder range.

H. Warranty: 18 months minimum from the time acceptance by City.

2.02 LEVEL RECORDER

A. Manufacturer: Foxboro Model 740R (740RA-A3300) or approved equal.

B. Description: Digital circular, 7-day-pen recorder, 2-pin 4-20 mA signals, display indicator, one-year supply of 0-30 foot range or sized to match wet well depth.

C. Display: Brilliant 2-line 20-characters per line.

D. Input: Two 4-20 mA signals.

E. Accuracy: Display (+/- 0.1% of input span), recording (+/- .25% of input span), supply voltage (less than 0.025% of span within +/- 10% of reference operating supply voltage).

2.03 LEVEL FLOATS

A. Manufacturer: Flygt Model ENV-10 (740RA-A3300) or approved equal.

B. Description: Direct acting encapsulate tear drop electrical switch.The float body is polypropytlend with pvc cable. Tear drop contains mechanical switch rated for 250 VAC / 10 Amps. Set the switch for normally open (NO) there wire single pole double throw. (SPDT). Include pvc coated weight the polypropylend chain for mounting Input: Two 4-20 mA signals.

C. Sensitivity: 9-inches of movement.

2.04 PRESSURE PRESSURE INDICATING TRANSMITTER

1. Type:

   a. Microprocessor based intelligent type. The process line acts directly on the internally mounted ceramic diaphragm of sensor and deflects it by a very small amount. A pressure-proportional range in the capacitance is measured by the electrodes on ceramic substrate and diaphragm. The transmitter electronics convert this capacitance signal to a 4-20 mA DC signal.

2. Function/Performance

   a. Power Requirement: 10.5 to 42.4 VDC. External power supply and power conditioner shall be provided.

   b. Output: One analog 4 mA to 20 mA

   c. Engineering Units: gauge pressure.

   d. Accuracy: ± 0.1 of the calibrated range or better

e. Stability: Combined temperature effects shall be less than 0.2 % of the maximum span per 50 degrees F temperature change.

f. Operating Pressure Range: 0 to 300 psig (or as required by plans and specifications).

g. Operating Temperature Range: - 40 to 185 °F (-40 to 85 °C)

h. Operating Humidity Ratio: 0-100 relative humidity %

i. Overpressure: The transmitter shall withstand 1600 psi without damage.

j. Burst Pressure: 10000 psi

3. Physical:

a. Process Connection: 316-stainless steel. Material shall be compatible with process fluid where the transmitter is installed. The contractor shall consult with the manufacturer for the proper diaphragm material on all chemical applications.

b. Drain/Vent Valve: 316-stainless steel on all water applications. Material shall be compatible with process fluid where the transmitter is installed. The contractor shall consult with the manufacturer for the proper diaphragm material on all chemical applications.

c. Process Isolation Diaphragm: 316-stainless steel. Material shall be compatible with process fluid where the switch is installed. The contractor shall consult with the manufacturer for the proper diaphragm material on all applications.

d. Transmitter Housing Material: Aluminum with polyurethane coating.. All mounting brackets and hardware shall be 316-stainless steel.

e. Display: A local integral display shall be provided.

f. Sensor Fill Fluid: Suitable for the process fluid being measured. When used for chemical metering service, the fill fluid shall be rated for the chemical being measured.

g. Flushing Connection: Two ½” connections shall be provided.

h. Electrical Classification: Intrinsically safe for Class I and Class II, Division 1 locations.

4. Accessories Required:

   a. Provide span and zero adjustment at each transmitter.

   b. Provide hand held programmer(s) as specified under tools and test equipment.

   c. For each transmitter provide a Model SBZ43 manifold as manufactured by D/A Manufacturing Co., Inc,or as supplied by the transmitter manufacturer and mounting brackets as required. The manifold shall be Type 316-stainless steel and provide the following modes of operation:

      (1) Normal Mode

      (2) Zeroing Mode

      (3) Isolation Mode

      (4) Calibration Mode

      (5) Blow-down Mode

5. Manufacturer(s)

   a. Rosemount 2051 or 3051

   b. Foxboro I/A Series

   c. Endress + Hauser

   d. Siemens

   e. Or Approved Equal.

2.05 POWER MONITOR (City of Houston plant on-site lift station only or as need for large capacity site.)

A. Manufacturer: Siemens Energy & Automation PAC4200, or approved equal.

B. Measurements: Voltage (L-L, L-N, 3-ph Avg), Current (Per Phase, 3-ph Avg), Apparent Power, Active Power, Power Factor, Frequency, 6 Limit Values.

C. Harmonics Monitoring: 3rd to 31st

D. Load Curve Recording: 40 days with 15-minute measuring period, Fixed block or rolling block

E. Event Recording: At least 4000 events with priority control and selectable warning levels

F. Clock: Real-time clock with calendar

G. Display: Backlit LCD.

H. Configuration: Via front panel or with Sentron PowerConfig Software supplied with unit

I. Communications: Profibus-DP to PLC via Expansion Module.

J. Digital Inputs and Outputs: One multifunctional input, One multifunctional output.

K. Certifications: cULus, CE, C-Tick, GOST.

L. Temperature Ratings: -10 to 55 deg. C operating.

M. Power: 95 to 240 VAC

2.06 CONTROL POWER TRANSFORMERS

A. Transformer: NEMA ST 1 machine tool transformer with isolated secondary winding.

B. Power Rating: 250 VA or 200 percent power requirement, whichever is greater.

C. Voltage Rating: 480/240 volt primary, 120 volt secondary, single phase.

2.07 PHASE/VOLTAGE MONITOR RELAY

A. Manufacturer, Product: Diversified Electronics Inc.; Model PBD Series or approved equal.

B. Description: All three phases monitored individually for preselected under and over voltage limit phase loss, phase unbalance, phase reversal, frequency shift and phase shift. Automatic reset after adjustable release delay when line conditions return to normal.

C. Indicators: LED indicators for under and over voltage limit.

D. Output Rating: DPDT, 3 amps resistive at 600 VAC.

E. Phase Sequence: ABC.

F. Sampling Time: 2 seconds.

G. Spare Unit: In addition to the unit installed, furnish one spare phase/voltage monitor relay.

2.08 TERMINAL BLOCKS

A. Manufacturers

1. Bussmann.

2. Phoenix Contact.

3. General Electric Company.

4. Weidmuller.

5. Allen Bradley.

B. Substitutions: Comply with Section 01630 - Product Substitution Procedures.

C. Terminal Blocks: Provide isolated fused snap-on type terminal blocks.

D. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 volts.

E. Signal and Control Terminals: Modular construction type suitable for channel mounting with tubular pressure screw connectors; 300 volt rating.

F. Provide color-coded (green/yellow) ground bus terminal block, with each connector bonded to enclosure.

2.09 SURGE PROTECTION AND SUPPRESSION DEVICES

A. Definitions

1. TVSS: Transient Voltage Surge Suppressor

2. SPD: Surge Protection Devices

B. Codes and Reference Standards

1. The TVSS / SPD shall comply with the following standards:

a. UL Listed or recognized to UL 1449, 2nd edition

b. Application Guide A and IEEE C62.41.1-2002 Category C area

c. IEC 61024/ Application Guide A

d. National Electrical Code

e. IEC 61643-1

C. General

1. The TVSS / SPD shall be available in a non enclosed Din rail mounted version or mounted in a suitable enclosure.

2. The TVSS / SPD components can be either a self contained wired in unit or a modular unit with field replacement capability without the removal of any wires.

3. TVSS/ SPD for 4-20ma shall be available in either series or parallel connection depending on the application.

4. The TVSS/ SPD shall be capable of supporting local and or remote alarming for failure notification.

D. Main Power Panel Requirements

1. Facility incoming voltage of 3 phase 480/277 AC or 3 phase 120/240 AC will require TVSS/ SPD protection with the following requirements:

a. 50 KA per IEC 61024 or 100 KA each phase per ANSI/IEEE C62.41

b. MOV, Arc Chute or Hybrid technology is acceptable

c. Response time: 1< nanosecond or di/dt rise for lighting strikes

d. Din Rail mounted or suitable enclosure

e. Multi-modes of protection (minimum L, N, and G)

2. Manufacturer

a. Surge Suppression Incorporated, Advantage SHDLA-3Y2

b. Dehn, Dehnguard P-R Series

c. Phoenix Contact, Combo Trab SYS FT+CT-VAL 480,277 rail kit

d. Or City of Houston approved equivalent

E. Secondary Power Panel Requirements

1. Secondary power panels supplying power to single phase 120/ 240 VAC or 120 VAC systems will require TVSS/ SPD protection with the following requirements:

   a. 40 KA each leg per ANSI/ IEEE

   b. MOV or Hybrid technology is acceptable

   c. Response time: <1 nanosecond

   d. Din Rail mounted or suitable enclosure

2. Manufacturer

   a. Surge Suppression Incorporated, Advantage SKLA-1S1

   b. Dehn, Dehnguard Series

   c. Phoenix Contact, Plugtrab PT2-PE/S 120AC-ST with PT-BE/FM base

   d. Or City of Houston approved equivalent

F. 4-20 ma Instrumentation Loops

1. Surge current rating of 10 KA per ANSI/ IEEE

2. The TVSS/ SPD must be base with interchangeable circuit protection

3. Din Rail mounted.

4. Shall have means for field testing.

5. Manufacturer

   a. Surge Suppression Incorporated, S-CL48-2DIN

   b. Dehn, Blitzductor CT-ME-30

   c. Phoenix Contact, Plug Trab PT1x2-24DC-ST Plug with PT1x2 base

   d. Or City of Houston approved Equivalent

G. Testing Requirement

1. Vendor shall provide verifiable third party test results of the stated specification of TVSS/ SPD

H. Warranty

1. 25 Year unlimited, free replacement unit or replacement parts for all Malfunctioning TVSS/ SPD devices

I. Listed manufacturers or approved equal

1. Dehn
2. Phoenix Contact
3. Surge Suppression Inc.

2.10 ACCESSORIES

A. Plastic Raceway: Plastic slotted wireway with snap-on locking covers.

B. Manufacturer

1. Anixter Bros., Inc.
2. Delaware Industries, Inc.
3. Panduit Corp.
4. Iboco

PART 3: EXECUTION

3.01 INSTALLATION

A. Furnish complete enclosure, factory tested and ready for installation and field termination.

B. Terminate wiring with spade lugs at terminal strips corresponding to designations on Drawings.

C. When not installed in plastic wireways, such as along back of door, neatly bundle and support air tubing and internal panel wiring with self-adhesive nylon clips. Provide adequate slack for proper door operation without damage to wiring or tubing.

D. Identification: Identify system components in accordance with Section 16195 - Wiring and Conduit Identification.

1. Identify conductors and termination points (device and relay terminals).

2. Identify transmitters, switches and devices with stainless steel tags.

3. Provide nameplates for panel-mounted devices and instruments as shown on Drawings.

3.02 SYSTEM TESTING

A. Perform system testing as required by individual component Sections. Calibrate and adjust components for proper operation. Submit 6 copies of Manufacturer's Installation Inspection, Field Calibration and Field Testing Reports. Replace components found to be defective.

END OF SECTION

Section 13471

CONTROL CABINET ENCLOSURES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Indoor and outdoor control cabinets for Lift Station instrumentation.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

B. ANSI/NFPA 70 - National Electrical Code (NEC).

C. Underwriters Laboratories, Inc. (UL).

D. Factory Mutual (FM).

E. Occupational Safety and Health Administration (OSHA).

F. American National Standards Institute (ANSI).

1.04 SUBMITTALS

A. Conform to Section 01330 - Submittal Procedures.

B. Product Data: Provide manufacturer's product literature and specifications.

C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Paragraph 1.04, Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

1.05 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70 (NEC).

B. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and shown; install in accordance with UL requirements.

1.06 EXTRA MATERIALS

A. Provide two keys for each cabinet; key locks as directed by City Engineer to operate in current City of Houston master keying system.

B. Insert half-size blackline prints on rite in the rain all weather writing paper model 8511 of the complete wiring diagrams, schematics, and loop diagrams applicable to each control panel in a clear plastic envelope and store in a suitable print pocket or holder inside each control panel.

PART 2: PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers

1. Rittal,

2. Hennessey Products, Inc.

3. Hoffman Engineering.

4. Hammond Manufacturing

5. The EMF Company.

6. Rose Enclosure.

7. Weigman Company.
8.
9. N.E.M.A. Enclosure Mfg. Co.

B. Substitutions: Comply with Section 01630 - Product Substitutions and Procedures.

2.02 INDOOR CONTROL CABINETS

A. Enclosure: NEMA 250, Type 12; if requested by City Engineer, obtain Underwriters Laboratory, Inc. approval after completion.

B. Enclosure Size: As indicated on Drawings; or, if not indicated, at least 72 inches high by 20 inches deep by 48 inches wide, or larger, as required to mount equipment indicated to U.L. Standards.

C. Backboard for mounting terminal blocks and components: 12 gauge steel, finished in white enamel.

D. Fronts: Steel pan-type doors with concealed stainless steel hinges, held closed by stainless steel 3-point latch operable by pistol-grip handle.

E. Provide solid metal barriers to separate compartments containing control wiring operating at less than 50 volts from power wiring.

F. Clean surfaces to remove dirt and corrosion residue. Phosphatize for corrosion protection. Prime with two coats, and finish with one coat, of factory-applied textured polyurethane, minimum 5 mils thickness, color as selected by City Engineer from manufacturer's standard colors.

G. Panel Construction: Provide panel stiffeners and bracing. Fully gasket doors. Weld seams and grind smooth.

H. Conduit Entrances: Bottom entry unless otherwise indicated on Drawings.

I. Material: Minimum 12 gauge steel.

J. Finish: Enamel; gray outside, white inside.

K. Provide convenience outlets and internal fluorescent lighting, as shown on Drawings.

L. Nameplates: On the outside of each cabinet’s inner door, provide motor data nameplate information for each pump motor; copy all information exactly as shown on each motor nameplate. Provide engraved laminated plastic nameplates; black letters with white background; fasten to outside of cabinet door of each motor starter section with stainless steel screws. Provide nameplates for all devices within panel.

M. Install wiring in open-slot plastic wiring duct.

N. On indoor panels install a 4-inch passive vent in the side near the top and near the bottom of an adjacent side panel. These vents shall have removable filters to resist dust and insect entry.

2.03 OUTDOOR CONTROL CABINETS

A. Enclosures: NEMA 3 type 5052-H32 aluminum with 0.125 inch thickness 5052 H32 aluminum back panel for mounting components. If requested by City Engineer, obtain inspection and approval by Underwriters Laboratory, Inc., after installation of control system in cabinet.

B. Enclosure Size: As indicated on Drawings, or if not indicated, at least 72 inches high by 48 inches wide by 36 inches deep, or larger, as required to accommodate equipment and as indicated in UL standards.

C. Material: Exterior and interior enclosure doors, shelves and component enclosures: Fabricate of 14 gauge type 316 stainless steel or 0.125 inch thick type 5052-H32 aluminum.

D. Doors: Stainless steel pan-type construction, with full-length stainless steel piano hinge (for stainless steel or aluminum). Equip exterior door with padlock, heavy-duty locking pistol-grip handles and 3-point latching mechanism of the draw roller type (0.750 inch minimum diameter rollers). Handles shall be 3/4 inch minimum diameter stainless steel. Equip interior doors with flush quarter-turn closure devices. Equip interior and exterior doors with neoprene gaskets.

E. Provide rain shield with 1 inch drip lip for outdoor cabinets to protect against direct sun radiation and rainfall. Design shield to provide 3-1/2 feet of cover front and back and 6 inches of cover on the sides. Design shield shall have a 1-inch open panel door clearance. Shielding material: Type 316 stainless steel or type 5052-H32 aluminum.

F. Nameplates: On the outside of each cabinet's inner door, provide motor data nameplate information for each pump motor; copy all information exactly as shown on each motor nameplate. Provide engraved laminated plastic nameplates; black letters with white background; fasten to outside of cabinet door of each motor starter section with stainless steel screws. Provide nameplates for all devices within panel.

G. In each cabinet section, provide a 120V convenience outlet and a switched 40 watt minimum fluorescent light fixture, with 0 degrees F ballast in each section.

H. Inside and outside of cabinet shall be smooth and free from burrs.

I. If aluminum cabinet, hinges shall be .090 inch thick minimum, aluminum, and shall have .250 inch diameter stainless steel hinge pin. Hinge leaves shall not be exposed externally when door is closed.

J. NEMA 4X enclosures shall have all bolt holes gasketed.

K. A divider of same material and thickness as the cabinet shall be added to divide electrical components and wiring from instrumentation and pneumatic components and wiring.

PART 3: EXECUTION

3.01 EXAMINATION

A. Verify that surface and job conditions are ready for construction; report unsatisfactory conditions to the City Engineer. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Transport, handle and install products in accordance with manufacturer's instructions.

B. Install on prepared pads. Anchor securely at each corner. Shim and grout as required to form a watertight seal.

C. Install cabinet fronts plumb.

D. Field-cut bottom conduit entrance openings for outdoor cabinets. Seal removable plates with silicone sealant.

E. Install ground rod and equipment ground conductor.

F. Install separate instrument ground lug and ground conductor; connect to common station ground grid.

G. Mount devices to allow removal and reinstallation without backboard removal. Use stainless steel mounting hardware.

H. Except for nameplate fasteners, mounting or other hardware shall not penetrate panel exterior.

I. Exterior panels: Mount with stainless steel anchor bolts and ground to the station ground field. Install and test ground field to provide maximum 5 ohm resistance to ground in accordance with Section 16170 - Grounding and Bonding.

J. Provide door restraints for outer and inner doors to positive lock and hold doors open at 115 degrees minimum.

K. Label all wires with heat shrink markers per Section 16195.

END OF SECTION

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SECTION 15010
BASIC MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.01 WORK INCLUDED

A. General requirements for acceptance, provision, and installation of piping, mechanical, heating, ventilating, and air conditioning system components, equipment, and related accessories are described in this Division and on Drawings and Data Sheets for piping, heating, ventilating, and air conditioning. Divisions 15 Specifications shall be applicable to Plumbing and HVAC disciplines unless specifically noted otherwise.

B. Provisions for the shipment, delivery, receiving, unloading, storage, on-site transportation, installation, connection, support, alignment, lubrication, adjustment, securing, and grouting, for equipment are specified under this Division.

C. On-site transportation, placement, leveling, securing, support, alignment, lubrication, adjustment, connection of required piping services and grouting for process and utility equipment purchased under separate purchase order are described under this Division.

D. Provision and installation of all other related mechanical and piping system components specified and required under this Division for proper establishment of fully operational installed process equipment.

E. Provision and installation of all other items and equipment specified and required under this Division.

F. Wherever the words "furnish", "provide", "furnish and install", "provide and install" and similar phrases occur, it is the intent that the materials and equipment described be furnished, installed connected, tested, and made ready for operation under this Division, unless specifically noted to the contrary.

1.02 QUALITY ASSURANCE

A. Codes and Standards: Work shall be governed by the latest edition of codes and standards in Section 15011, Codes and Standards as supplemented by specific section references.

B. Guarantee in writing that Work under Division 15, Plumbing, Heating, Ventilating, and Air-Conditioning (HVAC) will be free from defective materials and for one (1) year after final acceptance as a minimum performance level. Some equipment may be required to have a different time span, as listed in other Sections. Submit in accordance with requirements of Owner's General Conditions.

C. Provide equipment installation personnel having minimum of 3 years experience in setting, installing, aligning, and adjusting equipment installed under these Divisions.

D. Provide items whose design and configuration are approved by authorities having jurisdiction and that have been reviewed by Owner's Representative.

E. Provide furnished items that are new, first grade, physically and chemically suitable for intended application unless written permission is obtained from the Owner's Representative to reuse certain materials, devices or equipment.

F. Provide Manufacturer's standard nameplate for each item of equipment furnished under this Division. Refer to Section 15190 Mechanical Identification for further identification requirements.

1.03 SUBMITTALS

A. Shop Drawings and Manufacturer's Data: Submit in accordance with requirements of Owner's General Conditions.

1. Submit complete list of proposed manufacturers of all major items of Contractor-furnished equipment within 30 days of Owner-Contractor agreement.
2. Submit Shop Drawings and operating instructions as set forth in these Contract Documents.
3. Unless otherwise specified within this Division, submit shop drawings for Contractor-furnished equipment and pre-purchased equipment installed by Contractor, piping system and accessories, and duct system and accessories for review prior to commencement of work including, but not limited to, following:
   a. Complete Manufacturer's descriptive data including technical data.
   b. Pipe connection sizes and types.
   c. Materials of construction.
   d. Dimensions and weight.
   e. Performance data and operating curves.

f. Electrical data, including wiring diagrams.
g. Installation recommendations.
h. Spare parts list.
i. Recommended maintenance.
j. Drawings for fabrication and installation of piping and duct systems.
k. Pipe layout w/Vents and low pt drains identified.

4. Process Shop Drawing data to ensure that it conforms to the requirements of the Drawings and Specifications and that there are no omissions and/or duplications.
5. Each shop drawing submission shall designate the exact item offered; unidentified items on Manufacturer's data sheets are not acceptable. Each submitted for equipment such as pumps, air handlers, fans, etc. shall be accompanied by its respective performance and operating curve.
6. In each case, the various material submissions of related items, procured from a single Manufacturer or Supplier, shall be assembled in brochures or in other suitable package form and shall not be submitted in a multiplicity of loose sheets.
7. The Shop Drawings shall include room by room tabulations of air distribution devices, fire dampers, plumbing fixtures, carriers, drains, valves and similar items.

B. Operating Instructions:

1. At completion of Work but prior to receipt of final payment, submit three (3) sets of complete operation and maintenance instructions for Contractor-furnished systems, controls, and equipment. Each set shall be neatly bound and identified on cover by name of system described, identification numbers of equipment covered by contents of manual, and names of Owner, Engineer, and Contractor. Include in bound volumes operation and maintenance procedures and one copy of all reviewed shop drawings for equipment installed under this Division but including equipment furnished by others.

C. Certificate of Approval:

1. At substantial completion of this portion of Work, submit to Owner's Representative eight copies of written certification that:
   a. All systems and equipment have been installed in accordance with Contract Documents and Manufacturer's recommendations.
   b. Safety and operating controls are functioning properly.
   c. Tests of piping, and HVAC systems have been satisfactorily completed.
   d. Cleanroom certification.

e. Upon completion of work, provide Owner with a Certificate of Approval from such authorities as may have jurisdiction.
f. Obtain timely inspections of the installation by the constituted authorities. Remedy any and all deficiencies to the satisfaction of the inspecting authority.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Shipment and Delivery:

1. Identify equipment or shipping containers with following:
   a. Item name.
   b. Item number, if any.
   c. Purchase order number.
   d. Manufacturer and model number.
   e. Destination.
   f. Owner's name.
   g. Contractor's name.
2. Receive, unload, remove from crate, and inspect all equipment and items specified and required under this Division for proper execution of this portion of Work.
3. Protect all connections, fluid passages, working parts, and linings of items furnished under this Division from weather and physical damage during shipment.
4. Upon receipt of items at Project site, examine surfaces and working parts for defects and damage.
5. Return defective or damaged parts to Supplier for repair or replacement so that schedule of this portion of Work is not impaired.
6. Identify all documents certifying quality and compliance with Specifications and deliver to Owner's Representative.

B. Storage:

1. Store items in dry, clean areas, safe from damage.
2. Maintain security and condition of all storage areas while items are stored.
3. Store pipe and equipment off floor or off ground.
4. Store small items and loose materials in clearly labeled, neatly arranged bins.
5. Protect ends of pipe, valves, and fittings from weather and abuse; keep open ends sealed or covered until removed for installation.

6. Store equipment and motors in safe, clean, dry areas, with open ends, ventilation inlets, and pipe connection points covered until removed for installation.
7. Store nonmetallic pipe, cement, adhesives, and solvents in cool, clean areas and in accordance with Manufacturers' instructions.
8. Store all stainless steel on wood.
9. Protect equipment subject to damage from falling objects with suitable protective covers.
10. Mark with purchase order number and equipment number and deliver to storage area spare parts and small items crated with equipment but not installed by Contractor under this Division.
11. At all times take every precaution to properly protect apparatus from damage. Include erecting temporary shelters to protect apparatus stored at the Site, cribbing of apparatus above the floor of the construction, and covering of apparatus in the uncompleted building with plastic sheeting or other protective coating. Failure on the part of the Contractor to comply with the above to the satisfaction of the Owner's Representative will be sufficient cause for the rejection of the pieces of apparatus in question.
12. Responsibility for the protection of apparatus shall extend to presently installed apparatus. Erect temporary sheltering structures, provide temporary bracing and supports, or cover equipment as required or directed to afford proper protection.

C. Handling:

1. Unload, unpack, and handle items with extreme care; use slings, cradles, or other appropriate appurtenances.
2. Utilize lifting points provided to move equipment.
3. Prevent contact of stainless steel and copper alloys with carbon steel.
4. Handle items in accordance with special instructions of Manufacturer or Suppliers.
5. Adequately grease all machined surfaces.
6. Move items within building such that floors are not gouged or marred.
7. Repair or replace parts damaged during handling at no additional cost to Owner so that schedule of this portion of work is not impaired.
8. If part of equipment crate serves as a skid, leave bolted to equipment until just prior to transfer of equipment to its final location.
9. Protect painted and machined surfaces where exposed; avoid denting, marring, or unduly stressing equipment parts.

1.05 SEQUENCING

A. Coordinate installation of equipment, equipment accessories, system accessories, and piping with installation of:

1. Electrical cable trays and conduit.
2. Ductwork.
3. Horizontal and vertical support systems.
4. Slabs and trenches.
5. Any items dependent on piping system for support:
   a. Coordinate installation of equipment with placement of supports and foundations and placement of associated or connected systems.
   b. Progress Schedule: Contractor shall coordinate progress schedules of all other Contractors and shall work in accordance with schedules for completion of Contract.

1.06 ENGINEERING DRAWINGS

A. Drawings are not intended to show complete or accurate details of buildings, equipment, ductwork and piping in every respect. They indicate general layout, approximate locations, relations and arrangements and are not intended to show details of Manufacturer's equipment Details of equipment shall be furnished by Manufacturer and Contractor for Owner's Representative approval.

B. Contractor: Define locations and relations in the field and as satisfactory to Owner. Take all field measurements and be responsible therefor.

C. Not all details of piping systems are shown on Drawings, nor are they specified herein. Piping shall be such as to legally pass all inspections by Local Plumbing Inspection Department, State and Federal Authorities and Insurance Company having jurisdiction, and any changes or additions which may be necessary to obtain such inspection and approval shall be made by the piping contractor as a part of this Contract without additional cost to Owner.

1.07 SUBSTITUTIONS AND SPACE ALLOCATIONS

A. Comply with the General Conditions.

B. Products: Comply with requirements as indicated in the General Conditions.

C. Space Allocations: Comply with requirements as indicated in the General Conditions.

D. Substitutions: Comply with requirements as indicated in the General Conditions.

PART 2 PRODUCTS

2.01 MATERIALS

A. In describing an item of equipment, it may be described singularly, even though there may be a multiplicity of identical items. Also, where a description is only general in nature, the exact size, duty, space arrangement, horsepower requirement and other data shall be determined by reference to plans, details and schedules.

B. Equipment called for on the plans and not listed herein shall be provided and installed as though it were fully described herein. Similarly, equipment called for herein shall be completely provided and installed, whether fully detailed or not on the plans and/or schedules.

C. Provide pipe, pipe system accessories, duct accessories, and equipment attachments unaffected by conditions of service and adjacent atmosphere.

D. Furnish all tools, cap screws, nuts, steel shims or shim stock, cinch anchor, anchor bolts, bolt sleeves, and proper quantities and grades of lubricant required to properly install, secure, lubricate and adjust equipment, including items purchased under separate purchase order and installed under this Division.

E. Provide proper quantities and grades of chemicals and appropriate media required to clean and test equipment.

F. Erection Equipment:

1. Provide and maintain equipment required to transport, erect, and install all items, including those purchased under separate purchase order.
2. Equip power operated equipment with pneumatic tires or rubber treads if used within building.
3. Maintain motor operated equipment such that no oil or grease is dropped on finished floors.

G. Provide OSHA approved guards for belt drives and motor couplings. Provide 1/2 inch hole in guard at center of equipment drive shaft where belt drive is used.

H. Interchangeability:

1. Provide completely interchangeable components, assemblies, and parts where such items have the same part number.
2. All interchangeable components shall be interchangeable without modification.

I. No asbestos or asbestos containing products are allowed.

1. Where dimensions, ratings, and characteristics are not known or specified, determine compliance using Manufacturer's design limits.

PART 3 EXECUION (NOT USED)

END OF SECTION

SECTION 15011
CODES AND STANDARDS

PART 1 GENERAL

1.01 SUMMARY

A. This section identifies agencies and societies that prepare codes, standards and regulations which govern work described in Division 15 Plumbing, Heating, Ventilating, and Air-Conditioning (HVAC).

B. Where specific articles, sections, divisions or heading of applicable code or standard are not given, conform to complete code or standard except where provisions in code or standard conflict with Contract Documents. In such cases confer with A/E to determine governing requirement.

1.02 BUILDING CODES AND GOVERNMENT REGULATIONS

A. Comply with all Latest Building Codes, including International Codes and City of Houston Amendments:

1. International Building Code: IBC 2012.
2. International Plumbing Code: IPC 2012.
3. International Mechanical Code: IMC 2012.
4. International Fire Code: IFC 2012.
5. National Electric Code: NEC 2014.
6. Energy Code: IECC 2009.

B. Comply with regulations of all authorities having jurisdiction including local codes, statutes and ordinances.

C. Obtain permits and arrange inspections required by codes applicable to this Section. Submit written evidence that required permits, inspections, and code requirements have been secured.

D. Comply with Owner’s Insurance Underwriter Requirements.

1.03 STANDARDS

A. Specifications and standards of the following technical societies, associations and organizations are by reference made a part of these specifications; unless otherwise indicated, comply with requirements and recommendations applicable practices, methods and standards prepared by these organizations:

AGMA	American Gear Manufacturer's Association
AISC	American Institute of Steel Construction
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
API	American Petroleum Institute
ARI	Air Conditioning and Refrigeration Institute
ASA	American Standards Association
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AVSS	American Vacuum Society
AWWA	American Water Works Association
AWS	American Welding Society
CGA	Compressed Gas Association
CISPI	Cast iron Soil Pipe Institute
CRSI	Concrete Reinforcing Steel Institute
EPA	Environmental Protection Agency
FM	FM Global
HI	Hydraulic Institute
IEEE	Institute of Electrical and Electronics Engineers
IES	Institute of Environmental Sciences
MSS	Manufacturer's Standardization Society of the Valves and Fitting Industry
NBS	National Bureau of Standards, U.S. Department of Commerce
NEBB	National Environmental Balancing Bureau
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
NSC	National Safety Code
OSHA	Occupational Safety and Health Administration

PDI	Plumbing and Drainage Institute
SMACNA	Sheet Metal and Air Conditioning Contractor's National Association
SSPC	Steel Structures Painting Council
UL	Underwriter's Laboratories

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUITION (NOT USED)

END OF SECTION

SECTION 15012
CERTIFICATION

PART 1 GENERAL

1.01 WORK INCLUDED

A. This Specification section pertains to all systems specified in Division 15 Plumbing, Heating, Ventilating, and Air-Conditioning (HVAC).

1.02 MANDATORY CERTIFICATIONS

A. Written test compliance shall be submitted to Owner's authorized representative for the following:

1. Pressure test of all pressure piping systems.
2. Equipment performance test.
3. Lubrication.
4. HVAC/Test and Balancing.

B. Notification: Provide Owner's authorized representative 24 hour notice prior to any testing. Owner may elect to be present or not.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SUBMITTALS

A. When the Work of this Division is completely installed, balanced and in permanent operating condition, the Contractor shall submit written certification in six copies to Owner that all systems and/or items of equipment are installed in accordance with Drawings, Specifications and manufacturer's recommendations and that safety and operating controls are functioning properly.

B. Tests of mechanical systems required and specified under the work of Division 15 Plumbing, Heating, Ventilating, and Air-Conditioning (HVAC) shall be logged, certified and submitted to the Owner's Representative.

END OF SECTION

SECTION 15050
BASIC MECHANICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 DESCRIPTION

A. The following generally define materials and methods to be used for fabrication, erection, and installation of piping systems, duct systems, and other HVAC components. These provisions are in addition to the requirements included in the other Division 15 Specifications and Drawings and are intended to supplement the Drawings. In case of conflict the Drawings shall take precedence over this section.

1.02 WORK INCLUDED

A. Provide and install all equipment and materials, constituting piping, and duct systems indicated on Drawings, including miscellaneous materials not specified as part of piping systems.

1.03 QUALITY ASSURANCE

A. Provide new, full weight, full length, equipment, duct, scale-free pipe, fittings and valves of best available quality.

B. Guarantee all materials to be as specified prior to delivery.

C. Arrange for inspection of all piping, pipe fittings and valves prior to installation and replace defective materials.

1.04 REFERENCES

A. Applicable Standards:

1. ANSI 21.11, Rubber Gasket Joints for Ductile Iron and Gray Iron Pressure Pipe and Fittings.
2. ANSI B2.1, Pipe Threads.
3. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings, class 25, 125, 250, and 800.
4. ANSI B16.3, Malleable Iron Threaded Fittings.
5. ANSI B16.5, Steel Pipe Flanges and Flanged Fittings, Including Rating for Class 150, 300, 400, 600, 900,1500, and 2500.
6. ANSI B16.9, Factory Made Wrought Steel Buttwelding Fittings.
7. ANSI B16.10, Face to Face and End to End Dimensions of Ferrous Valves.
8. ANSI B16.11, Forged Steel Fittings, Socket Welding and Threaded.

9. ANSI B16.18, Cast Copper Solder Joint Pressure Fittings.
10. ANSI B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
11. ANSI B16.34, Steel Valves, Flanged and Butt Welding End.
12. ANSI B18.2.1, Square and Hex Bolts and Screws, Including Askew Head Bolts, Hex Cap Screws, and Lag Screws.
13. ANSI B18.2.2, Square and Hex Nuts.
14. ANSI B31.1, Power Piping.
15. ANSI B31.3, Chemical Plant and Petroleum Refinery Piping.
16. ANSI B36.10, Welded and Seamless Wrought Steel Pipe.
17. ANSI B36.19, Stainless Steel Pipe.
18. ASTM A53, Specification for Pipe, Steel, Black and Hot Dipped, Zinc¬Coated, Welded and Seamless.
19. ASTM A105, Specification for Forging, Carbon Steel, for Piping Components.
20. ASTM A106, Specification for Seamless Carbon Steel Pipe for High Temperature Service.
21. ASTM A120, Specification for Pipe, Steel, Black and Hot Dipped Zinc Coated (Galvanized) Welded and Seamless, for Ordinary Uses.
22. ASTM A126, Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
23. ASTM A182, Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service.
24. ASTM A194, Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High Temperature Service.
25. ASTM A197, Specification for Cupola Malleable Iron.
26. ASTM A216, Specification for Carbon Steel Castings Suitable for Fusion Welding for High Temperature Service.
27. ASTM A 234, Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
28. ASTM A307, Specification for Carbon Steel Externally Threaded Standard Fasteners.
29. ASTM A312, Specification for Seamless and Welded Austenitic Stainless Steel Pipe.
30. ASTM A351, Specification for Austenitic Steel Castings for High Temperature Service.
31. ASTM A395, Specifications for Ferritic Ductile Iron Pressure Retaining Castings for Use at Elevated Temperatures.
32. ASTM A403, Specification for Wrought Austenitic Stainless Steel Pipe Fittings
33. ASTM A436, Specification for Austenitic Gray Iron Castings.
34. ASTM A494, Specification for Nickel and Nickel Alloy Castings.
35. ASTM A563, Specification for Carbon and Alloy Steel Nuts.
36. ASTM B61, Specification for Steam or Valve Bronze Castings.

37. ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
38. ASTM B124, Specification for Copper and Copper Alloy Forging Rod, Bar and Shapes.
39. ASTM B148, Specification for Aluminum-Bronze Sand Castings.
40. ASTM D1330, Specification for Rubber-Sheet Gaskets.
41. ASTM D1784, Specification for Ridged Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
42. ASTM D1785, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
43. ASTM D2146, Specification for Propylene Plastic Molding and Extrusion Materials.
44. ASTM D2466, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
45. ASTM D2564, Specification for Solvent Cements for Poly (Vinyl Chloride) PVC) Plastic Pipe and Fittings.
46. ASTM D2855, Recommended Practice for Making Solvent Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
47. ASTM F438, Specification for Socket Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
48. ASTM F441, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
49. AWWA C500, Gate Valves 3 inch through 48 inch For Water and Other Liquids.
50. CISPI 301, Specification for Hubless Cast Iron Sanitary System.
51. MSS SP 6, Standard Finishes for Contact Faces of Pipe Flanged and Connecting End Flanges of Valves and Fittings.
52. MSS SP 61, Pressure Testing of Steel Valves.
53. MSS SP 67, Butterfly Valves.
54. MSS SP 70, Cast Iron Gate Valves, Flanged and Threaded Ends.
55. MSS SP 71, Cast Iron Swing Check Valves, Flanged and Threaded Ends.
56. MSS SP 72, Ball Valves with Flanged or Butt Welding Ends for General Service.
57. MSS SP 78, Cast Iron Plug Valves, Flanged and Threaded Ends.
58. MSS SP-80, Bronze Gate, Globe, Angle and Check Valves.
59. MSS-SP-82, Valve Pressure Testing Methods.
60. MSS-SP-84, Steel Valves Socket Welding and Threaded Ends.
61. MSS-SP-85, Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.
62. MSS-SP-88, Diaphragm Type Valves.

1.05 SUBMITTALS

A. Submit in accordance with requirements of General Conditions.

B. Submit:

1. Manufacturer's written certification of compliance with requirements of regulatory agencies.
2. Manufacturer's written certification of piping and duct material design pressure rating.
3. Duct, and pipe fitting dimensional data.
4. Complete listing with manufacturer's name, of all duct and pipe, fittings, and accessories to be used.
5. Sources of materials.
6. Submit list of valves proposed for project to Architect/Engineer for approval prior to purchase.
7. Submit catalog cuts and descriptive information for all valves showing dimensions, end connection type and size, materials of construction, chemical and physical properties of materials, operational data, rated design pressure, and manufacturer's installation recommendations.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Ship, receive, and handle duct and pipe and fittings so as not to damage joining surfaces, coating, lining, and as required to prevent cracking or breakage.

B. Repair or replace all coatings, linings, or wrapping damaged during delivery, transportation, and storage.

C. Utilize appropriate tools, equipment, and procedures to handle and transport pipe.

D. Conform to Section 23 05 00, General Provisions.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide equipment of the manufacturer's most recent standard design. Equipment designs that have not been previously used successfully in an industrial application are not acceptable.

B. Provide 1 quart and 2 spray cans of each standard paint used from each equipment and/or materials supplier for touchup. Adequately label paint cans to identify where they are to be used. When equipment is involved the label shall at a minimum, include the Owner's equipment tag number.

2.02 EQUIPMENT IDENTIFICATION

A. Provide equipment with a stainless steel identification tag pinned in place in a readily accessible location with the following information at a minimum (when applicable):

1. Manufacturer's name.
2. Manufacturer's model number.
3. Date of manufacture.
4. Design operating conditions.
5. Design pressure and temperature.
6. Serial number.
7. Materials of construction.
8. Code stamp.
9. RPM.
10. Electrical power requirements.

2.03 MATERIALS

A. Material and Dimensional Requirements:

1. Cast Iron Flanges: ANSI B16.1.
2. Steel Flanges: ANSI B16.5, ASTM A105, ASTM A182 (high temperature).
3. Malleable Iron Fittings: ANSI B16.3, ASTM A197.
4. Bolts and Screws: ANSI B18.2.1, ASTM A307, ASTM A193.
5. Nuts: ANSI B18.2.2, ASTM A563, ASTM A194.
6. Nonmetal Gaskets: ASTM D1330 (rubber), ANSI B16.21

B. Modular Wall and Casting Seals: Link-Seal as manufactured by Thunderline Corporation.

C. Provide proper quantities and type of cement, adhesives, tools, and heat sources for attachment and installation of non-metallic pipe and accessories.

D. Provide all inserts required for proper execution of this portion of work.

2.04 EQUIPMENT ACCESS

A. Access Panels:

1. Provide access panels in walls or ceilings, as necessary, to allow proper access to equipment for maintenance. Size and location of access panel is to be determined by the contractor based on actual equipment purchased and final location of installed equipment. Size and location of access panel shall be approved by Engineer through shop drawings. Refer to Division 8.

PART 3 EXECTION

3.01 INSPECTION

A. Inspect the work to ensure the installation and workmanship is in accordance with these Specifications and acceptable industry standards for the work being done.

B. Examine all surfaces of duct, pipe, piping specialties, valves, accessories, and equipment to be joined; clean on all metal obtrusions, discontinuities and debris. Remove and replace promptly all materials disclosed to be cracked, damaged or defective as that schedule of this portion of work is not impaired.

C. Provide minimum notice of 5 days to owner's representative in advance of all tests and inspections.

D. For each structure or building included in Work, the following formal inspections by owner's representative shall be conducted:

1. Underground work prior to concealment.
2. Aboveground work prior to concealment.
3. Final inspection after completion of Work.
4. Additional inspections as ordered by Owner.

E. Where shop inspection is specified, no surfaces or parts are to be painted until the inspection is complete.

F. Make materials, equipment, and workmanship available to inspection at any time by the Owner. Correct any work, materials, or equipment not in accordance with the Contract Documents.

G. Equipment:

1. Prior to commencing equipment installation, inspect work or other trades and verify that work of other trades and work under this Division is complete to point where equipment installation may properly commence.
2. Verify that equipment installation may proceed in accordance with relevant codes and standards.
3. Notify Owner's Representative immediately in event of discrepancy; do not proceed with installation in areas of discrepancy until such discrepancies are resolved.

H. Provide flanges or unions at:

1. All final connections to equipment,
2. Both sides of all control valves, in-line equipment and instruments,
3. Intervals in screwed lines,
4. Where frequent dismantling of piping or removal of in-line items is required,
5. Where non-metallic pipe systems cannot be otherwise joined.
6. Where necessary to provide clearance for dismantling equipment, and
7. In pipelines on both sides of items as needed.

I. General Requirements, Installation of Non-Metallic Piping:

1. Install in accordance with recommendations of pipe manufacturer, using materials supplied or recommended by pipe manufacturer.
2. Do not subject pipe to any weight or force other than weight of pipe and contents.
3. Install restraints as indicated on Drawings, as required, and as recommended by pipe manufacturer to allow for differential expansion induced by difference in temperature at time of installation and final operating temperature.
4. Take precautions necessary to prevent damage to outside surfaces of pipe and fittings during installation.
5. Install supports for pipe as indicated on Drawings and/or Section 40 05 15, Piping Support Systems.
6. Install drains and cleanouts in drainage systems as required and as indicated on Drawings.
7. Cut smooth, and clean ends of piping before applying any solvent cement, joint sealant, and heating appurtenance.
8. Assemble joints completely in accordance with applicable ASTM requirements and accepted industry standards, exercising care not to damage pipe surfaces.
9. Install adapters as required for connection to traps, nonplastic pipe, bell and spigot pipe, and threaded connections.
10. Do not thread plastic pipe.
11. Align pipe so as to provide uniform slope and eliminate strain form piping and joints.
12. Support piping such that pipe is not abraded or distorted and so as to allow free movement.
13. Do not expose pipe to sunlight during or after installation.
14. If necessary, bend pipe carefully to minimum radius in accordance with manufacturer's instructions for type of material and wall thickness; otherwise, use fittings for changes in direction.
15. Do not handle or install solvent cemented pipe until joints have "cured" for minimum 1 hour.

16. Install pipe so that identifying marks are clearly visible.
17. Apply primers only as required by pipe manufacturer.
18. Install fusion welded joints in accordance with instructions of pipe manufacturer.
19. Join solvent cemented polyvinyl chloride pipe in accordance with ASTM D2855.

3.02 PREPARATION

A. Cutting and Patching:

1. Perform cutting and patching required to install piping, ductwork, mechanical system components and mechanical equipment.
2. Secure approval of Owner's Representative before cutting where strength or appearance of finished work is affected.
3. Finish to match existing or prior work.

B. Lubricated all moving parts of equipment installed under this Division thoroughly prior to operation in accordance with manufacturer's instructions.

C. Place, set, and install all sleeves and inserts required to route and install services under this Division.

3.03 INSTALLATION

A. Equipment:

1. Install equipment in accordance with the requirements of the manufacturer.
2. Equipment Manufacturer's Responsibility and Services:
   a. Provide a manufacturer's representative for major equipment and operating systems to assist the Contractor during installation.
   b. Provide the manufacturer's representative onsite during initial startup of equipment in the presence of Owner and Owner’s Representative.
      1) Provide a prestart check of piping, valves, control devices, control panels, and equipment.
      2) Calibrate and adjust equipment and controls for operation at the specified design conditions.
   c. Upon the completion of equipment startup, provide instructional time with the Owner's personnel to review the operations and maintenance manuals and perform each step necessary for startup, shutdown, troubleshooting, and routine maintenance. Schedule the instructional time through the Owner.

3. Mounting and shimming:
   a. Mount equipment as shown on the Drawings. Provisions for mounting special equipment on spring isolators, snubbers, and inertia bases are specified in Section 23 05 53, Identification for HVAC Piping and Equipment.
   b. Level the equipment by means of steel wedges (steel plates and steel shims). Wedge taper shall not be greater than 1/4 inch per foot. Use double wedges to provide a level-bearing surface for the equipment. Service each pair of wedges in their final positions with one tack weld on each side after leveling is complete. Execute wedging in a manner that will prevent a change in level or springing of the baseplate when the anchor bolts are tightened.
      1) Adjust rotating equipment assemblies such that the driving units are properly aligned, plumb, and level with the driven units and interconnecting shafts and couplings.
      2) Check rotating equipment for proper alignment with dial indicators. The alignment must be within the tolerances required by the equipment manufacturer. The final alignment check shall be witnessed by the Owner’s Representative.
   c. After the equipment has been set in position, align, and shim to the proper elevations, grout the space between the bottom of the baseplate and the concrete foundation and/or inertia base with a poured nonshrinking grout as specified in Architectural Specifications.

B. Install suitable designed guides, anchors, braces, and couplings wherever required to limit movement of piping resulting from induced hydraulic reduce transmission of such stresses and resulting forces; utilize minimum number necessary.

C. Equipment:

1. Rig, install, and assemble equipment as required to constitute complete workable system in satisfactory operating condition.
2. Place, level, support, lubricate, align, grout, and firmly shim equipment components as required and as indicated on Drawings, including equipment purchased under separate purchase order. Grout equipment after equipment is set and aligned.
3. Provide required slope where equipment is required to be sloped.
4. Where indicated, install vibration dampening mounts in accordance with manufacturer's instructions.
5. Set equipment bases or baseplates on clean foundation and level and align before connecting piping. Tighten anchor bolts and grout base.

6. Conceal outside end of shims on rotary equipment so as to have minimum 1/4 inch covering.
7. Align driver and drive shaft assembly of driven equipment after grout has set to within manufacturer's required tolerances before giving shaft couplings and anchor bolts final tightening.
8. Motor Alignment:
   a. Over 50 hp: Light shrink fit on coupling halves.
   b. 50 hp and Under: Light tap fit.
9. Install all piping and electrical connections before attempting operation of equipment, including equipment purchased under separate purchase order.
10. Follow manufacturer's supplied instructions installing all equipment.
11. Modify assemblies, locations, and orientation only as required by shop drawings and as approved by Owner's Representative.
12. Maximum Runout For Rotating Parts: 0.0005 inch, dial indicator.
13. Install equipment such that tightening anchor bolts or connecting pipe does not induce stresses or distortion.
14. Recheck alignment of equipment, including equipment purchased under separate purchase order, after base plate is tightened, after piping has been connected and again at operating temperature after equipment has been tested and operated at conditions of service. Realign as necessary.
15. After grouting, leveling, aligning, and securing are complete and after shims are removed where specified by manufacturer, make internal and external connections of all piping, tubing, and other utilities as required to all equipment, including equipment purchased under separate purchase order, and check connections for tightness, correctness, and integrity prior to initial operation.
16. Install dowels where required after alignment and after connecting piping.
17. Level and bolt in place equipment not supported on foundation.
18. If no anchor bolts are indicated, fasten equipment to concrete floors with required number and size of expansion bolts extending minimum 3 inches into concrete.
19. Engage services of qualified manufacturer's field engineers to supervise and assist in installation, start-up, and testing of equipment installed under this Division.
20. Unless otherwise required by Owner's Representative, start up, adjust, and conduct performance tests for each system and each item of utility equipment, specified in this Division and purchased under separate purchase order, in accordance with manufacturer's instructions and to satisfaction of owner's representative. Notify Owner's Representative minimum three days in advance of performance test.

D. Bolted Connections:

1. Punch, drill, or ream bolt holes and remove burrs.
2. Use washers, lock washers, and self-locking nuts as indicated and as required.
3. Use screw threads conforming to National or Unified forms in accordance with NBS and other applicable standards.
4. Do not use sheet metal screws.
5. Use machine bolts where access to and use of nuts may not be possible and where unbolting may be required. In the case of the latter, use sufficient metal thickness to assure that bolt thread engagement is at least equal to thickness of the corresponding nut.
6. Secure machine bolts in place with properly sized lock washers.

3.04 FIELD QUALITY CONTROL

A. Install piping and mechanical systems so as to pass all inspections by local, state, and federal plumbing authorities having jurisdiction, insurance company having jurisdiction, and all other governing agencies. Changes or additions necessary to obtain approvals of inspecting agencies shall be included as part of work under this Division.

B. Clean all accessible parts of extraneous materials; smooth external surfaces and bevel all edges where practical.

C. Before installing piping, examine proposed routing proposed routing location for clearance of piping, structural steel, ductwork, conduit, walls, and roofing already present and as proposed by other trades and other trades and coordinate routing with items and services to avoid interference.

D. During installation, test pipe coating with suitable electronic tester and correct deficiencies.

E. Equipment Installation:

1. If structure floor or overhead steel is used to support equipment, protect, brace, and shore up floor to avoid damage to floor or any supporting structure or member.
2. Repair all damage to floor, structure, steel, or any portion of Work resulting from improper support or handling of equipment.
3. Use only flat shims for leveling.
4. Do not use jack nuts on anchor bolts for leveling.
5. Use only machine bolts of proper size for bolting in place equipment supported on structural steel.
6. Clean external surfaces of equipment at completion of this portion of Work to remove dust, debris, rust, weld splatter, and concrete.

7. Remove all erection equipment, tools, and debris from area when equipment is installed and ready for operation.
8. Examine equipment installation for secure placement and proper assembly and orientation; perform all work required to produce workable, operable installation.

F. Provide certification for items and completed portions of work including following:

1. Conformance of all work under Division 15 with Contract Documents.
2. Lubrication.
3. HVAC testing and balancing agency (including complete report)
4. Manufacturer's or vendor's shop drawings for equipment, including dimensions, design data, instrumentation, and electrical data.
5. Testing of mechanical systems as specified in this Division.

G. Provide opportunity for Architect/Engineer and Owner's Representative to inspect installation of all equipment, piping, valves, ductwork, and any other portion of work under this Division at any time or stage and witness performance tests; perform any remedial work required and indicated by inspection.

H. Repair or correct all leaks, defects, failures, or inoperative conditions.

I. Insure that areas and systems comprising completed work under this Division are left in proper working order, clean, and free of debris and surplus materials.

J. Install overhead piping and ductwork such that, unless otherwise indicated or specified, minimum overhead clearances to underside of flanges, pipe insulation, duct, duct insulation, or bottom of structural supports is as follows:

1. Above Floors Within Building: 10' - 0".
2. Above Elevated Wales and Platforms: 10' - 0".
3. Above All Other Outside Areas at Grade: 10' - 0".

K. If not specified and done under Section 09 90 00, Painting and Coating, touch up areas, where equipment finishes or coatings are marred or damaged during handling, transporting, and installing, with manufacturer's recommended type and thickness of touch-up paint to match existing finish.

3.05 SAFETY CONSIDERATIONS

A. Install equipment with suitable access clearances for maintenance or removal of replaceable parts and components and with necessary unions or flanges to perform the maintenance or removal without removing the connecting appurtenances.

B. Where equipment requiring periodic maintenance cannot be reached by normal walkways because of interference with ductwork, piping, or other obstructions, provide an alternate safe means of access. These may include construction of an overhead platform with stairway or ladder ends and safety railings or handholds or walk-through duct plenums with hinged access doors or as required to meet OSHA standards for safe maintenance procedures.

3.06 CLEANING, STARTUP, AND ADJUSTING

A. The Contractor is responsible for proper operation of systems, minor subsystems, and services provided under this section. Coordinate startup procedures, calibration, and system checkout with all subcontractors involved. System operational problems shall be diagnosed; correctional procedures shall be initiated with the various contractors as required to bring the system into compliance with the design and the problem then shall be rechecked to verify that the system operates normally.

B. Thoroughly clean parts of the installation at the completion of the work. Clean up and remove from the premises refuse material, crates, and rubbish arising from the work. Remove, clean, and reinstall all filters. Check belt-drive tensions and alignments. Lubricate motors and bearings in accordance with the manufacturer's service manuals prior to equipment startup. Provide a lubrication schedule for every item of equipment furnished.

END OF SECTION

SECTION 15190
MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Nameplates.
2. Tags.
3. Stencils.
4. Labels.
5. Lockout devices.

B. Related Sections: Section 09 90 00, Painting and Coating: Execution requirements for painting specified by this section.

1.02 REFERENCES

A. American Society of Mechanical Engineers: ASME A13.1, Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. See Division 1, General Requirements for submittal procedures.

B. Product Data: Submit manufacturers catalog literature for each product required.

C. Shop Drawings: Submit list of wording, symbols, letter size, and color coding for mechanical identification and valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures, and installation.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.04 CLOSEOUT SUBMITTALS

A. See Division 1, General Requirements for closeout procedures.

B. Project Record Documents: Record actual locations of tagged valves; include valve tag numbers.

1.05 QUALITY ASSURANCE

A. Conform to ASME A13.1 for color scheme for identification of piping systems and accessories.

B. Maintain one copy of each document on Site.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.

1.07 PRE-INSTALLATION MEETINGS

A. See Division 1, General Requirements for pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.08 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.01 NAMEPLATES

A. Manufacturers:

1. Craftmark Identification Systems.
2. Safety Sign Co.
3. Seton Identification Products.
4. Other approved equal.

B. Product Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

2.02 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inches diameter.

B. Metal Tags Brass with stamped letters; tag size minimum 1-1/2 inches diameter with finished edges.

C. Information Tags: Clear plastic with printed "Danger," "Caution," or "Warning" and message; size 3-1/4 by 5-5/8 inches with grommet and self-locking nylon ties.

D. Tag Chart: Typewritten letter size list of applied tags and location plastic laminated.

2.03 STENCILS

A. Stencils: With clean cut symbols and letters of following size:

1. Up to 2 inches Outside Diameter of Insulation or Pipe: 1/2 inch high letters.
2. 2-1/2 to 6 inches Outside Diameter of Insulation or Pipe: 1-inch high letters.
3. Over 6 inches Outside Diameter of Insulation or Pipe: 1-3/4 inch high letters.
4. Ductwork and Equipment: 1-3/4 inches high letters.

2.04 LABELS

A. Description: Aluminum, size 1.9 by 0.75 inches, adhesive backed with printed identification.

2.05 LOCKOUT DEVICES

A. Lockout Hasps: Anodized aluminum hasp with erasable label surface; size minimum 7-1/4 by 3 inches.

B. Valve Lockout Devices: Steel device preventing access to valve operator, accepting lock shackle.

PART 3 EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.02 INSTALLATION

A. Install identifying devices after completion of coverings and painting.

B. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.

C. Install labels with sufficient adhesive for permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.

D. Install tags using corrosion resistant chain. Number tags consecutively by location.

E. Identify HVAC equipment with plastic nameplates.

F. Identify control panels and major control components outside panels with plastic nameplates.

G. Identify ductwork with stenciled painting. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION

SECTION 15200
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:

1. Air Force: A-A-58092, Tape, Antiseize, Polytetrafluorethylene.
2. American Association of State Highway and Transportation Officials (AASHTO): HB-17, Standard Specifications for Highway Bridges.
3. American Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
4. American Society of Mechanical Engineers (ASME):
   a. Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
   b. B1.20.1, Pipe Threads, General Purpose (Inch).
   c. B16.1, Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250.
   d. B16.3, Malleable Iron Threaded Fittings Classes 150 and 300.
   e. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
   f. B16.9, Factory-Made Wrought Buttwelding Fittings.
   g. B16.11, Forged Fittings, Socket-Welding and Threaded.
   h. B16.15, Cast Copper Alloy Threaded Fittings Classes 125 and 250.
   i. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   j. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   k. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings Classes 150, 300, 600, 900, 1500, and 2500.
   l. B16.25, Buttwelding Ends.
   m. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
   n. B31.1, Power Piping.
   o. B31.3, Process Piping.
   p. B31.9, Building Services Piping.
   q. B36.10M, Welded and Seamless Wrought Steel Pipe.
5. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.

6. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
   c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   f. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
   g. C153/A21.53, Ductile-Iron Compact Fittings.
   h. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
   i. C606, Grooved and Shouldered Joints.
7. American Welding Society (AWS):
   a. Brazing Handbook.
   b. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   c. D1.1/D1.1M, Structural Welding Code - Steel.
   d. QC1, Standard for AWS Certification of Welding Inspectors.
8. ASTM International (ASTM):
   a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
   d. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   f. A135/A135M, Standard Specification for Electric-Resistance-Welder Steel Pipe.
   g. A139/A139M, Standard Specification for Electro-Fusion (Arc)–Welded Steel Pipe (NPS 4 Inches and Over).
   h. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   i. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   j. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   k. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.

l. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
n. A197/A197M, Standard Specification for Cupola Malleable Iron.
o. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
p. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
q. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
r. A276, Standard Specification for Stainless Steel Bars and Shapes.
s. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
t. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
u. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
v. A320/A320M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
w. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
x. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
y. A403/A403M, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
z. A409/A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
aa. A536, Standard Specification for Ductile Iron Castings.
bb. A563, Standard Specification for Carbon and Alloy Steel Nuts.
cc. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
dd. A743/A743M, Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
ee. A744/A744M, Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
ff. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.

gg. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
hh. B32, Standard Specification for Solder Metal.
ii. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
jj. B61, Standard Specification for Steam or Valve Bronze Castings.
kk. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
ll. B75/B75M, Standard Specification for Seamless Copper Tube.
mm. B88, Standard Specification for Seamless Copper Water Tube.
nn. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
oo. B462, Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, and UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
pp. B464, Standard Specification for Welded UNS N08020 Alloy Pipe.
qq. B474, Standard Specification for Electric Fusion Welded Nickel and Nickel Alloy Pipe.
rr. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
ss. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
tt. D413, Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate.
uu. D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.
vv. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
ww. D1330, Standard Specification for Rubber Sheet Gaskets.
xx. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
yy. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
zz. D2000, Standard Classification System for Rubber Products in Automotive Applications.
aaa. D2310, Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

bbb. D2464, Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
ccc. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
ddd. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
eee. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
fff. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
ggg. D2996, Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
hhh. D3222, Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
iii. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
jjj. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
kkk. D4894, Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials.
lll. D4895, Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion.
mmm. F423, Standard Specification for Polytetrafluoroethylene (PTFE) Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges.
nnn. F436, Standard Specification for Hardened Steel Washers.
ooo. F437, Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
ppp. F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
qqq. F441/F441M, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
rrr. F493, Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
sss. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ttt. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

9. FM Global (FM).
10. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43, Wrought and Fabricated Butt-Welding Fittings for Low-Pressure, Corrosion Resistant Applications.

11. NSF International (NSF):
    a. ANSI 61: Drinking Water System Components - Health Effects.
    b. ANSI 372: Drinking Water System Components - Lead Content.
12. National Electrical Manufacturers Association (NEMA): LI 1, Industrial Laminating Thermosetting Products.
13. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.02 DEFINITIONS

A. Submerged or Wetted:

1. Zone below elevation of:
    a. Top face of channel walls and cover slabs.
    b. Liquid surface or within 1 feet above top of liquid surface.
    c. Top of tank wall or under tank cover.

1.03 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Building Service Piping: ASME B31.9, as applicable.
    a. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Codelocal plumbing code.
3. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.
4. Thrust Restraints:
    a. Design for test pressure shown in Piping Schedule.
    b. Allowable Soil Pressure: 1,000 pounds per square foot.
    c. Low Pressure Pipelines:
        1) When bearing surface of the fitting against soil provides an area equal to or greater than area required for thrust restraint, concrete thrust blocks will not be required.
        2) Determine bearing area for fittings without thrust blocks by projected area of 70 percent of internal diameter multiplied by chord length for fitting centerline curve.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
   a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
4. Thrust Blocks: Concrete quantity, bearing area on pipe, and fitting joint locations.
5. Dissimilar Buried Pipe Joints: Joint types and assembly drawings.
6. Pipe Corrosion Protection: Product data.
7. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance, in accordance with Section 01 61 00, Common Product Requirements
   a. Pipe and fittings.
   b. Factory applied resins and coatings.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Flanged Pipe and Fittings: Manufacturer's product data sheets for gaskets including torqueing requirements and bolt tightening procedures.
4. Qualifications:
   a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
   b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
   c. Welders:
      1) Continuity log for welders and welding operators.
      2) Welder qualification test records conducted by Contractor or manufacturer.

5. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
6. Nondestructive inspection and testing procedures.
7. Test logs.
8. Laboratory Testing Equipment: Certified calibrations, manufacturer's product data, and test procedures.
9. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection**,** Observation, and Testing.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
   a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
   b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
   e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
4. Contractor's CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Provide services of independent inspection and testing agency for welding operations.

1. Note, the presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.06 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.

2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.

B. Diameters Shown:

1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.03 JOINTS

A. Grooved End System:

1. Rigid type.
2. Use of flexible grooved joints allowed where shown on Drawings or with prior approval by Engineer.
3. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.

B. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.

C. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

D. Mechanical Joint Anchor Gland Follower:

1. Ductile iron anchor type, wedge action, with break-off tightening bolts.
2. Thrust rated to 250 psi minimum.
3. Rated operating deflection not less than:
   a. 3 degrees for sizes through 12 inches.
   b. 2 degrees for sizes 14 inches through 16 inches.
   c. 1.5 degrees for sizes 18 inches through 24 inches.
   d. 1 degree for sizes 30 inches through 48 inches.
4. UL and FM approved.

E. Flexible Mechanical Compression Joint Coupling:

1. Stainless steel, ASTM A276, Type 305 bands.
2. Manufacturers:
   a. Pipeline Products Corp.
   b. Fernco Joint Sealer Co.

F. Mechanical connections of high-density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through-flanged connections consisting of the following:

1. Polyethylene stub end thermally butt-fused to end of pipe.
2. ASTM A240/A240M, Type 304 stainless steel backing flange, 125-pound, ASME B16.1 standard. Use insulating flanges where shown.
3. Bolts and nuts of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer’s standard. Retorque nuts after 4 hours.
4. Gaskets as specified on Data Sheet.

2.04 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute or “or-equal” will be allowed.

2.05 DOUBLE WALL CONTAINMENT PIPING SYSTEM

A. System components shall be pre-engineered, factory fabricated, tested, and assembled such that field assembly is minimized to primarily that of straight joints.

2.06 PIPE CORROSION PROTECTION

A. Coatings: See Section 09900, Painting and Coating, for details of coating requirements.

B. Heat Shrink Wrap:

1. Type: Cross-linked polyolefin wrap or sleeve with mastic sealant.
2. Manufacturer and Product: Raychem;.

C. Polyethylene Encasement (Bagging):

1. Encasement Tube: Black polyethylene encasement tube, 8 mils minimum thickness, conforming to AWWA C105/A21.5, free of gels, streaks, pinholes, foreign matter, undispersed raw materials, and visible defects such as tears, blisters, and thinning at folds.
2. Securing Tape: Thermoplastic tape, 8 mils minimum thickness, 1 inch wide, pressure sensitive adhesive face capable of bonding to metal, bituminous coating, and polyethylene encasement tube.

D. Insulating Flanges, Couplings, and Unions:

1. Materials:
   a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.9 working pressure rating equal to or higher than that of joint and pipeline.
   b. Galvanically compatible with piping.
   c. Resistant for intended exposure, operating temperatures, and products in pipeline.
2. Union Type, 2 Inches and Smaller:
   a. Screwed or solder-joint.
   b. O-ring sealed with molded and bonded insulation to body.
3. Flange Type, 2-1/2 Inches and Larger:
   a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
   b. Bolt insulating sleeves shall be provided full length between insulating washers.
   c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.

d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves.
e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of required washers, flanges, and gasket.

4. Flange Insulating Kits:
   a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
   b. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA LI-1, G-10 grade)**.**
   c. Insulating Washers: Fiberglass-reinforced epoxy (NEMA LI-1, G-10 grade).
   d. Steel Washers: Hardened steel, ASTM F436, 1/8 inch thick.
      1) Flange Diameters 36 Inches or Less: Provide two washers per bolt.
      2) Flange Diameters Larger Than 36 Inches: Provide four washers per bolt.
5. Manufacturers and Products:
   a. Dielectric Flanges and Unions:
      1) PSI, Houston, TX.
      2) Advance Products and Systems, Lafayette, LA.
   b. Insulating Couplings:
      1) Dresser; STAB-39.
      2) Baker Coupling Company, Inc.; Series 216.

2.07 THRUST BLOCKS

A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.08 THRUST TIES

A. Steel Pipe: Joint harness as specified in Section 40 27 01, Process Piping Specialties.

B. Buried Ductile Iron Pipe and Fittings: Unless restraint is otherwise specified or shown, conform to NFPA 24. Tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.

2.09 VENT AND DRAIN VALVES

A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.

B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless shown otherwise.

2.10 FABRICATION

A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer's identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by manufacturer.

2.11 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

B. Galvanizing:

1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

A. See Piping Schedule and Section 09900, Painting and Coating, for additional requirements.

B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions, except for damaged glass-lined pipe or PVDF-lined pipe that is to be promptly removed from Site.

3.03 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.1 **[B: B31.3] [C: B31.9]** for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.

B. Weld Identification: Keep paper record of which welder welded each joint.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding**.**
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions: Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on the weld area, or if ambient temperature is below 32 degrees F.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Quality: Meet requirements of governing welding codes.

3.04 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer .

D. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Grooved-End Joints:

1. Piping shall be grooved in accordance with manufacturer's latest published instructions and shall be accurately cut with tools conforming to coupling manufacturer's standards and to AWWA C606.
2. Install grooved joint couplings and gaskets in accordance with manufacturer's latest published installation instructions.

F. Soldered Joints:

1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

G. Brazed Joints for Refrigerant Piping:

1. Braze copper piping with silver solder complying with AWS A5.8/A5.8M.
2. Construct joints according to AWS Brazing Handbook, Chapter Pipe and Tube.
3. Inside of tubing and fittings shall be free of flux.
4. Clean parts to be joined with emery cloth and keep hot until solder has penetrated the full depth of the fitting and extra flux has been expelled.
5. Cool joints in air and remove flame marks and traces of flux.
6. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel the air.
7. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

H. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.

I. PVC and CPVC Piping:

1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

J. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
   a. General: As required for the type of joint to be made.
   b. Rubber Gasketed Joints: Remove sharp edges or projections.
   c. Push-On Joints: Bevel, as recommended by pipe manufacturer.
   d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

K. PVDF-Lined Steel Pipe Installation:

1. Cut, make up, and install pipe in accordance with pipe manufacturer's written instructions.
2. Weld vent extension half-couplings in-place prior to lining pipe.
3. Do not weld on pipe after lining is installed.
4. Prevent plugging of vent extensions with insulation or paint.

L. High-Density Polyethylene Piping:

1. Join pipes, fittings, and flange connections by means of thermal butt-fusion.
2. Perform butt-fusion in accordance with pipe manufacturer's recommendations as to equipment and technique.
3. Special Precautions at Flanges: Polyethylene pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.

M. Fiberglass Reinforced Piping:

1. Cut, fabricate, and install in accordance with manufacturer's written instructions.
2. Provide manufacturer's representative for instructing workers on proper installation and jointing methods.
3. Installation shall be made by workers experienced in FRP pipe lay-up techniques.

3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.

2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 1inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.06 INSTALLATION—BURIED PIPE

A. Joints:

1. Dissimilar Buried Pipes:
   a. Provide flexible mechanical compression joints for pressure pipe.
   b. Provide concrete closure collar for gravityandlow pressure (maximum 10 psi) piping or as shown.
2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.

B. Placement:

1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.15, Trench Backfill.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. Install closure sections and adapters for gravity piping at locations where pipe laying changes direction**.**
10. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
    a. Shorter pipe lengths.
    b. Special mitered joints.
    c. Standard or special fabricated bends.
11. After joint has been made, check pipe alignment and grade.
12. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
13. Prevent uplift and floating of pipe prior to backfilling.

C. Tolerances:

1. Deflection from Horizontal Line: Maximum 2 inches.
2. Deflection From Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.

4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.07 INSTALLATION—CONCRETE ENCASED

A. Provide reinforced concrete pipe encasement where shown on Drawings and where otherwise required. Some piping may be required to be concrete encased for pipe strength requirements that are included in the Specifications. Piping under and within the influence of buildings, utility trenches, vaults, slabs, and other structures shall be concrete encased. See details on Drawings for encasement requirements.

B. Where concrete encased piping crosses structure construction and expansion joints, provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.08 INSTALLATION—DOUBLE WALL CONTAINMENT PIPING SYSTEM

A. Install according to manufacturer's instructions.

B. Valves and equipment shall be supported independently from pipe. Anchor valves such that turning moment resulting from their operation will not be transmitted to pipe.

C. Centering Devices for Double Wall Containment Piping:

1. Center and support carrier pipe within the containment pipe with centering devices. Locate not less than every 9 feet, or within 24 inches of the termination of containment pipe on fabricated pieces.
2. Install centering devices such that leak detection cable (if specified) will be unrestricted and such that system maintains free drainage.

D. Following Installation and Testing:

1. Flush clean carrier and containment piping system.
2. Purge annular space of moisture with clean, dry nitrogen gas air.

3.09 LEAK DETECTION SYSTEM FOR DOUBLE WALL CONTAINMENT PIPING

A. Install in accordance with system manufacturer's instructions and recommendations.

3.10 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating, and as shown in Piping Schedule.
2. Buried: Wrap with polyethylene bagging.
3. Submerged or Embedded: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF/ANSI 61 approved epoxy.

B. Carbon Steel Pipe:

1. Exposed: As specified in Section 09900, Painting and Coating.
2. Buried:
   a. Pipe: Wrap with tape coating system as specified in Section 09900, Painting and Coating.
   b. Joints: Wrap with tape coating system as specified in Section 09900, Painting and Coating, or heat shrink wrap as specified herein.
3. Submerged or Embedded: Shop coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF/ANSI 61 approved epoxy.

C. Copper Pipe:

1. Exposed: As specified in Section 09900, Painting and Coating.
2. Buried:
   a. Pipe: **[A:]**
   b. Joints: **[B:]**

D. PVC and CPVC Pipe, Exposed: As specified in Section 09900, Painting and Coating.

E. Piping Accessories:

1. Exposed:
   a. Field paint black and galvanized steel, brass, copper, and bronze piping components as specified in Section 09900, Painting and Coating, as applicable to base metal material.
   b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.
2. Buried:
   a. Ferrous Metal and Stainless Steel Components: Coat with coal-tar epoxy as specified in Section 09900, Painting and Coating.

b. Bolts, Nuts, and Similar Items: Coat with bituminous paint.
c. Flexible Couplings, Grooved Couplings**,** and Similar Items: Wrap with heat shrink wrap or coat with cement.
d. Buried Valves and Similar Elements on Wrapped Pipelines: Coat with bituminous paint and wrap entire valve in polyethylene encasement.
e. Cement-Coated Pipelines: Cement coat appurtenances same as pipe.

F. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer's instructions.

G. Tape Coating System: As specified in Section 09900, Painting and Coating.

H. Heat Shrink Wrap: Apply in accordance with manufacturer's instructions to surfaces that are cleaned, prepared, and primed.

I. Insulating Flanges, Couplings, and Unions:

1. Applications:
   a. Dissimilar metal piping connections.
   b. Cathodically protected piping penetration to buildings and watertight structures.
   c. Submerged to unsubmerged metallic piping connections.
   d. Connections to existing metallic pipe.
   e. Where required for electrically insulated connection.
2. Pipe Installation:
   a. Insulating joints connecting immersed piping to nonimmersed piping shall be installed above maximum water surface elevation.
   b. Submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.
   c. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

J. Pipe Bonding for Buried Piping: As specified in Section 26 42 01, Pipe Bonding and Test Stations.

K. Cathodic Protection for Buried Piping: As specified in Section City of Houston Standard Specification for Cathodic Protection, and as shown.

3.11 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.
2. Exposed Piping: At all joints in piping.

B. Thrust Ties:

1. Steel Pipe: Attach with joint harness specified in Section 40 27 01, Process Piping Specialties.
2. Ductile Iron Pipe: Attach with socket clamps anchored against grooved joint coupling or flange.
3. Flanged Coupling Adapters: For exposed installations, install manufacturer's anchor studs through coupling sleeve or use dismantling joints.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

D. Thrust Blocking:

1. Place between undisturbed ground and fitting to be anchored.
2. Quantity of Concrete: Sufficient to cover bearing area on pipe and provide required soil bearing area as shown.
3. Place blocking so that pipe and fitting joints will be accessible for repairs.
4. Place concrete in accordance with Section 03 30 00, Cast-in-Place Concrete.

3.12 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.13 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.
3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.14 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines at all low and high point locations.

3.15 **INSULATION**

A. See Section 40 42 13, Process Piping Insulation.

3.16 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.

B. As specified in Section 09900, Painting and Coating.

3.17 PIPE IDENTIFICATION

A. As specified in Section **[A: 10 14 00, Signage] [B: 31 23 23.15, Trench Backfill] [C: 09900, Painting and Coating] [D: 09 90 04, Painting (Short Form)]**.

3.18 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:

1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.

5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code **[A: , ASME B31.1] [B: , ASME B31.3] [C: for Normal Fluid Service] [D: , except that] [E: 5] [F:] [G: percent of circumferential butt welds shall be random radiographed]**.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.19 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site [B: in accordance with Section 01 43 33, Manufacturers' Field Services,] to assist with unloading of the double wall containment piping system, system tests, containment pipe joint closure, installation and testing of leak detection system, and training of Owner's personnel in operation and maintenance of leak detection system. Manufacturer's representative shall complete a Manufacturer's Certificate of Proper Installation. Inspection and examination practices shall be according to ASME B31.3 for Normal Fluid Service.

3.20 CLEANING

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris instrument air lines with compressed air at 4,000fpm; do not flush with water.

C. Immediately after cleaning dry chlorine gas or liquid, service piping, dry to minus 40 degrees F dew point with dry compressed instrument air or compressed commercial grade nitrogen.

D. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

E. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

F. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.21 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification:

1. Piping Schedule.
2. Data Sheets.

Number	Title
15200.01	Cement-Mortar-Lined Ductile Iron Pipe and Fittings
15200.03	Carbon Steel Pipe and Fittings—General Service
15200.05	Glass,-Lined Carbon Steel Pipe and Fittings
15200.07	Galvanized Steel Pipe and Malleable Iron Fittings
15200.08	Stainless Steel Pipe and Fittings—General Service
15200.10	Polyvinyl Chloride (PVC) Pipe and Fittings

END OF SECTION

PIPING SCHEDULE LEGEND

SERVICE

A	Air
AHP	Air-High Pressure
ALP	Air-Low Pressure
RD	Roof Drain
SD	Storm Drain
SS	Sanitary Sewer
V	Vents
NPW	Non-Potable Water
SCM	Scum
RAS	Return Activated Sludge

EXPOSURE

ALL	All
BUR	Buried
EXP	Exposed
SUB	Submerged
ENC	Concrete Encased

MATERIAL

CLDI	Cement-Lined Ductile Iron
CMP	Corrugated Metal Pipe
COP	Copper
CPVC	Chlorinated PVC
DI	Ductile Iron

FRPX	Fiberglass Reinforced Plastic Pipe Type (X = 1 to 3)
GLDI	Glass-Lined Ductile Iron
GSP	Galvanized Steel Pipe
HDPE	High-Density Polyethylene
PCCP	Prestressed Concrete Cylinder Pipe
PSTL	PVDF-Lined Steel
PVC	Polyvinyl Chloride
PVDF	Polyvinylidene Fluoride
RCP	Reinforced Concrete Pipe
RSTL	Rubber-Lined Steel
SST	Stainless Steel
STL	Steel
VC	Vitrified Clay Pipe
WS	Fabricated Welded Steel

JOINT TYPE

FL	Flanged
GR	Grooved
HU	Hub and spigot
PRJ	Proprietary Restrained
RM	Restrained Mechanical
S	Screwed
W	Welded (including solvent and fusion)

PRESSURE TEST

G	Gravity Service: Test pressure is not shown on gravity services. Test to highest liquid level that pipe can be subject to.
H	Hydrostatic
I	In Service
P	Pneumatic
PC	Test per Uniform Plumbing Code
NA	Not Applicable

Piping Schedule

Service	Legend	Size(s) (In.)[1]	Exposure	Piping Material	Specification Section	Joint Type	Lining/ Coating[2]	Test Pressure and Type (psig-x), x = Type indicated in Legend	Pipe Color and Label	Remarks

[1]">" Greater Than
"<" Less Than
"<=" Less Than or Equal To
">=" Greater Than or Equal To
"All" All Sizes

[2]Coating system number as specified in Section **[A: 09 90 00, Painting and Coating] [B:]**, and as specified in Article Pipe Corrosion Protection.

SECTION 15200.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
General	Materials in contact with potable water shall conform to NSF 61 acceptance. Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of the specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).
Pipe	Buried Liquid Service Using **[A: Push-on] [B: , Mechanical] [C: , or]** Proprietary Restrained Joints: AWWA C111/A21.11, and AWWA C151/A21.51, pressure class conforming to Table 5 and Table 7 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Buried Air Service Using **[D: Push-on] [E: , Mechanical] [F: , or]** Proprietary Restrained Joints: AWWA C151/A21.51, pressure class conforming to Table 5 and Table 7 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Exposed Pipe Using Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-mortar: AWWA C104/A21.4. Glass: Completely fused above 1,400 degrees F, 6 mils to 10 mils thick, defects which expose base metal not greater than 0.01 percent of total lined surface, hardness greater than 5 on the Mohs scale, lining bonded sufficiently to withstand a metal strain of 0.001 inch/inch without damage to the glass lining, finished lined pipe not to deviate more than 0.0125 inch per foot of length from a centerline perpendicular to the flange face or square end of the pipe. Fast Fabricators, Inc., Ferrock MEH-32; Ceramic Coating Co., SL-31; VITCO Corp., SG-14. **[A: Ceramic-epoxy: Pipe and fittings to be ceramic epoxy lined shall not have been previously lined. Surface preparation shall be made to surfaces free of grease, oil, or other substance with**

SECTION 15200.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
	abrasive blasting using clean sand or grit abrasive. Lining shall be done within 8 hours of surface preparation and surfaces shall be reblasted if rusting appears before lining. Line with a total dry film thickness of 40-mils of ceramic epoxy. Ceramic epoxy shall be amine-cured Novolac epoxy with 20 percent minimum volume ceramic quartz pigment, Protecto 401 by Induron Coating, or equal. Lining shall be applied above 40 degrees F ambient temperature and shall not be applied to flange faces. Lining thickness shall be tested using a magnetic film thickness gauge. Lining integrity shall be tested on surfaces with a nondestructive, 2,500-volt dielectric resistance test.]
Fittings	Lined and coated same as pipe. **[A: Push-on: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psi minimum working pressure. American Cast Iron Pipe Co., Fastite Joint; U.S. Pipe and Foundry, Tyton Joint.]** **[B: Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psi minimum working pressure. Follower glands shall be ductile iron.]** Proprietary Restrained: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be achieved with removable metal elements fitted between a welded bar on the pipe barrel and the inside of the joint bell or fitting sizes smaller than 16 inches may be mechanical joint, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Assembled joints shall be rated for deflection in operation at rated pressure. Rated deflection shall be not less than 1-1/2 degrees for 36-inch and smaller pipe. Rated deflection shall be not less than 1/2 degree for 42-inch and larger pipe. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure; Victaulic. Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125

SECTION 15200.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
	flat face **[C: or ASME B16.1, Class 250 raised face]**. Gray cast iron will not be allowed.
Joints	**[A: Push-on: 250 psi minimum working pressure, AWWA C110/A21.10 and AWWA C111/A21.11. American Cast Iron Pipe Co., Fastite Joint; U.S. Pipe and Foundry, Tyton Joint.]** **[B: Mechanical: 250 psi minimum working pressure.]** Proprietary Restrained: 150 psi minimum working pressure. Clow Corp., Super-Lock; American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex. Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure; Victaulic. Flange: Class 125 flat face, **[C: or Class 250 raised face,]** ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. Branch connections 3 inches and smaller, **[D: except from glass-lined pipe,]** shall be made with service saddles as specified in Section 40 27 01, Process Piping Specialties. **[E: Branch connections, 3 inches and smaller from glass-lined pipe shall be made with glass-lined tee with a flanged branch for adapting to branch piping.]**
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.
Bolting	Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard. Class 125 Flat-Faced Flange: ASTM A307, Grade A carbon steel hex head bolts, ASTM A563, Grade A carbon steel hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. **[A: Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts; ASTM A194/A194M, Grade 8M hex**

SECTION 15200.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
	nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.] **[B: Class 250 Raised-Face Flange: ASTM A307, Grade B carbon steel hex head bolts, ASTM A563, Grade A carbon steel heavy hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.]**
Gaskets	General: Gaskets in contact with potable water shall be NSF 61 certified. **[A: Push-on] [B: , Mechanical] [C: , and]** Proprietary Restrained Joints; Water and Sewage Service: Rubber conforming to AWWA C111/A21.11. **[D: Push-on] [E: , Mechanical] [F: , and]** Proprietary Restrained Joints; Hot Air Service: EPDM or Viton and conforming to AWWA C111/A21.11. Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606. Flanged, Water, Sewage and Hot Air Services: 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D2000 4CA 415 A25 B35 C32 EA14 F19. Full face for Class 125 flat-faced flanges, flat-ring type for Class 250 raised-face flanges. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer’s standard.

END OF SECTION

SECTION 15202
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA): 3, Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   b. B16.44, Manually Operated Metallic Gas Valves for Use in Above Ground Piping Systems up to 5 psi.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
   a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   b. C500, Metal-Seated Gate Valves for Water Supply Service.
   c. C504, Rubber-Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm).
   d. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
   e. C509, Resilient-Seated Gate Valves for Water Supply Service.
   f. C510, Double Check Valve Backflow Prevention Assembly.
   g. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   h. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
   i. C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
   j. C541, Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
   k. C542, Electric Motor Actuators for Valves and Slide Gates.
   l. C550, Protective Interior Coatings for Valves and Hydrants.
   m. C606, Grooved and Shouldered Joints.
   n. C800, Underground Service Line Valves and Fittings.

6. ASTM International (ASTM):
    a. A276, Standard Specification for Stainless Steel Bars and Shapes.
    b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
    c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
    d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
    e. B61, Standard Specification for Steam or Valve Bronze Castings.
    f. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
    g. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
    h. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
    i. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
    j. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
    k. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
    l. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
    m. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
    n. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
7. Canadian Standards Association, Inc. (CSA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
8. Chlorine Institute (CI): Pamphlet 6, Piping Systems for Dry Chlorine.
9. FM Global (FM).
10. Food and Drug Administration (FDA).
11. International Association of Plumbing and Mechanical Officials (IAPMO).
12. Manufacturers Standardization Society (MSS):
    a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
    b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
    c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
    d. SP-88, Diaphragm Valves.
    e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

13. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. Underwriters Laboratories (UL).
16. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
    b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
    c. Power and control wiring diagrams, including terminals and numbers.
    d. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
    e. Sizing calculations for open-close/throttle and modulating valves.
    f. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for:
    a. Electric actuators; full compliance with AWWA C542.
    b. Butterfly valves; full compliance with AWWA C504.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
4. Tests and inspection data.
5. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.

D. Valve ends to suit adjacent piping.

E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.

F. Size operators and actuators to operate valve for full range of pressures and velocities.

G. Valve to open by turning counterclockwise, unless otherwise specified.

H. Factory mount operator, actuator, and accessories.

I. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

   1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE

A. Additional requirements relative to this section are shown on Electric Motor Actuated Valve Schedule located at the end of this section.

2.03 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

B. Valve materials in contact with or intended for drinking water service to meet the following requirements:

1. Materials to comply with requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
2. Coatings materials to be formulated from materials deemed acceptable to NSF/ANSI 61.

2.04 FACTORY FINISHING

A. General:

1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating.
3. Material in contact with potable water shall conform to NSF/ANSI 61.
4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be “safety yellow.”

B. Where epoxy lining and coating are specified, factory finishing shall be as follows:

1. In accordance with AWWA C550.
2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES

A. Gate Valves:

1. General:
   a. AWWA gate valves to be in full compliance with stated AWWA standard and the following requirements:
      1) Provide 2-inch operating nut and handwheel for AWWA gate valves 12 inches and smaller.
      2) Provide totally enclosed spur or bevel gear operator with indicator for AWWA gate valves 14 inches and larger.
      3) Provide Affidavit of Compliance per the applicable AWWA standard for AWWA gate valves.
      4) Mark AWWA gate valves with manufacturer's name or mark, year of valve casting, valve size, and working water pressure.
      5) Repaired AWWA gate valves shall not be submitted or supplied.
      6) AWWA C509 and AWWA C515 valves may be substituted for each other.

B. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 70-100.
         b) Nibco; T-580-70.
      2) Soldered:
         a) Conbraco Apollo; 70-200.
         b) Nibco; S-580-70.

2. Type V301 Ball Valve 2 Inches and Smaller for General Water and Air Service:
    a. Two-piece, full port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
        Manufacturers and Products:
        1) Threaded:
            a) Conbraco Apollo; 77-100.
            b) Nibco; T-585-70.
        2) Soldered:
            a) Conbraco Apollo; 77-200.
            b) Nibco; S-585-70.
3. Type V302 Actuator Ready Ball Valve 2 Inches and Smaller for General Water and Air Service:
    a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, actuator mounting pad, Type 316 stainless steel ball and stem, vented ball, reinforced PTFE seats and seals, adjustable packing nut, blowout-proof stem, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
    b. Manufacturers and Products:
        1) Conbraco Apollo; 71-140.
        2) Milwaukee; 20BSOR-02.
4. Type V303 Ball Valve 2 Inches and Smaller for Equipment Air System Shutoff:
    a. Two-piece, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, 125 psig rated, safety exhaust port to exhaust downstream side when valve is in closed position, zinc-coated steel locking handle with vinyl grip.
    b. Meets OSHA Regulation 29 CFR Part 1910.147 requirements.
    c. Manufacturers and Products:
        1) Conbraco Apollo; 75-100-41.
        2) Nibco; T-580-70-SV/T-585-70-SV.
5. Type V304 Ball Valve 2 Inches and Smaller for General Water and Air Service:
    a. Three-piece, full port, NPT threaded ends, bronze body and end pieces, hard chrome plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, zinc-plated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150 psi SWP, complies with MSS SP-110.

b. Manufacturers and Products:
   1) Threaded Ends:
      a) Conbraco Apollo; 82-100.
      b) Nibco; T-595-Y.
      c) Stockham; T-395 Series.
   2) Solder Ends:
      a) Conbraco Apollo; 82-200.
      b) Nibco; S-595-Y.
      c) Stockham; S-395 Series.

6. Type V306 Stainless Steel Ball Valve 2 Inches and Smaller:
   a. Two-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end piece, NPT threaded ends, ASTM A276 Type 316 stainless steel ball, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout proof stainless steel stem, stainless steel lever operator with vinyl grip, rated 1,000 psig CWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Conbraco Apollo; 76F-100 Series.
      2) Nibco; T-585-S6-R-66-LL.
7. Type V307 Stainless Steel Ball Valve 2 Inches and Smaller:
   a. Three-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end pieces, Type 316 stainless steel ball, NPT threaded ends, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout-proof stainless steel stem, stainless steel lever operator with vinyl grip, rated 800 psig to 1,000 psig CWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Conbraco Apollo; 86R-100/86-500 Series.
      2) Nibco; T-595-S6-R-66-LL.
8. Type V308 Stainless Steel Ball Valve 2 Inches and Smaller:
   a. Two-piece, standard port, NPT threaded ends, ASTM A351/A351M GR CF8M stainless steel body and end pieces, actuator mounting pad, Type 316 stainless steel ball and stem, vented ball, reinforced PTFE seats and seals, adjustable packing nut, blowout-proof stem, rated 1,500 psig WOG minimum, 150 psi SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Conbraco Apollo; 76-100.
      2) Nibco; T-580-S6-R-66-LL.
      3) Milwaukee; 20SSOR-02.

9. Type V309 Instrument Air Shutoff Valve 1/8 Inch to 3/4 Inch:
   a. Stainless steel body ball valve, nylon handle, tube fitting ends, PTFE seats and seals, panel nut, rated 1,500 psi minimum.
   b. Manufacturers and Products:
      1) Swagelok; 40 Series.
      2) Parker Hannifin; B Series.
10. Type V310 Ball Valve for Chlorine Liquid and Gas:
   a. 600-pound WOG, carbon steel body, monel ball and stem, reinforced Teflon seat, Teflon seals, double stem seal, lever operator, screwed ends, nonlubricated, and comply with the requirements of Chlorine Institute Pamphlet 6.
   b. Manufacturer and Product: ITT Camtite.
11. Type V318 Ball Valve 1 Inch and Smaller for In-Door Low Pressure Gas Service:
   a. Two-piece bronze or forged brass body and end piece, NPT threaded ends, hard chrome plated brass ball, PTFE seats and packing, yellow or red lever handle, rated pressure to 5 psi.
   b. Fully comply with AGA 3 or ASME B16.44, ANSI Z21.15/CSA 9.1, and CR91-002 for manually operated valves.
   c. Manufacturers and Products:
      1) Conbraco Apollo; Series GB-10.
      2) Nibco; GB-10.
12. Type V319 Ball Valve 2 Inches and Smaller for In-Door Main Burner Low Pressure Gas Service:
   a. Two-piece bronze or forged brass body and end piece, NPT threaded ends, hard chrome plated brass ball, PTFE seats and packing, plated steel lever handle with yellow vinyl grip, rated pressure to 5 psi, with cast-in pilot tap and plug.
   b. CSA approved and in full compliance with AGA 3, ANSI Z21.15/CSA 9.1, and CR91-002for manually operated valves.
   c. Manufacturers and Products: Conbraco Apollo; Series GB-50 Series.
13. Type V320 Vee-Ball Valve 1 Inch to 16 Inches:
   a. ASME B16.1 Class 150-pound flanged ends, Type 317 stainless steel body, heat treated nickel- or hard chromium-plated Type 317 stainless steel ball, splined-type, 17-4 PH stainless steel shafts, reinforced PTFE flow-ring seal, reinforced PTFE with stainless steel or Hastalloy sleeve bearings, and PTFE V-ring packing. Valve to have 300:1 rangeability and equal percentage characteristic.
   b. Manufacturers and Products:
      1) Fisher Controls: Design V150.
      2) DeZurik: VPB V-Port Ball Valve.

14. Type V330 PVC Ball Valve 2 Inches and Smaller:
    a. Rated 150 psi at 73 degrees F, with ASTM D1784, Type I, Grade 1 polyvinyl chloride body, ball, and stem, end entry, double union design, solvent-weld socket ends, elastomer seat, Viton or Teflon O-ring stem seals, to block flow in both directions. Provide pressure relief hole drilled on low pressure side of ball.
    b. Manufacturers and Products:
        1) Nibco; Chemtrol Tru-Bloc.
        2) ASAHI/America; Type 21.
        3) Spears; True Union.
15. Type V331 PVC Ball Valve 3 Inches and 4 Inches:
    a. Rated 150 psi at 73 degrees F, with ASTM D1784 Type I, Grade 1 PVC full port body, Teflon seat, Viton O-ring stem, face and carrier seals, end entry design with dual union, solvent-weld socket ends, or single union ball valve with flanged ends drilled to ASME B16.1. Provide pressure relief hole drilled on low pressure side of ball.
    b. Manufacturers and Products:
        1) Nibco; Chemtrol Tru-Bloc.
        2) ASAHI/America; Type 21.
16. Type V335 CPVC Ball Valve 2 Inches and Smaller:
    a. Rated 150 psi at 100 degrees F, 80 psi at 140 degrees, with ASTM D1784, Type IV, Grade 1 chlorinated polyvinyl chloride (CPVC) body, ball, and stem, end entry, double union design, with solvent-weld socket ends or single union ball with flanged ends drilled to ASME B16.1, replaceable Teflon seat, Viton or Teflon O-ring stem seals, to block flow in both directions. Provide pressure relief hole drilled on low pressure side of ball.
    b. Manufacturers and Products:
        1) Nibco; Chemtrol Tru-Bloc.
        2) ASAHI/America; Type 21.
        3) Spears; True Union.

C. Plug Valves:

1. Type V400 Eccentric Plug Valve 2 Inches and Smaller:
    a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, threaded ends, lever operator, cast-iron plug with round or rectangular port, plug coated with Buna-N, stem bearing lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber.

b. Manufacturers and Products:
   1) Pratt; Ballcentric.
   2) DeZurik; Style PEC.
   3) Milliken; Millcentric Series 603.

2. Type V405 Eccentric Plug Valve 3 Inches to 12 Inches:
   a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints, buried service mechanical joint ends, unless otherwise shown.
   b. Plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
   c. For buried service, provide external epoxy coating.
   d. Operators:
      1) 3-Inch to 4-Inch Valves: Wrench lever manual.
      2) 6-Inch to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.
   e. Manufacturers and Products:
      1) Pratt; Ballcentric.
      2) DeZurik; Style PEC.
      3) Milliken; Millcentric Series 600.

3. Type V406 Eccentric Plug Valve 14 Inches to 20 Inches:
   a. Nonlubricated type rated 150 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints, buried service mechanical joints ends, unless otherwise shown, plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
   b. Totally enclosed, geared, manual operator with handwheel, 2-inch nut or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.

c. For buried service, provide external epoxy coating.
d. Manufacturers and Products:
1) Pratt; Ballcentric.
2) DeZurik; Style PEC.
3) Milliken; Millcentric Series 600.

4. Type V407 Eccentric Plug Valve 24 Inches to 48 Inches:
a. Nonlubricated type rated 150 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1, buried service mechanical joints ends unless otherwise shown, plug cast iron port opening of no less than 70 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
b. Totally enclosed, geared, manual operator with handwheel, 2-inch nut, or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant.
c. For buried service, provide external epoxy coating.
d. Manufacturers and Products:
1) Pratt; Ballcentric.
2) DeZurik; Style PEC.
3) Milliken; Millcentric Series 600.

5. Type V408 Eccentric Plug Valve 3 Inches to 12 Inches for Digester Gas Service:
a. Nonlubricated type rated 175 psig working pressure, bubble-tight shutoff with gas pressure from one direction, body cast iron with flanged ends, plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearing lubricated stainless steel, stem seal multiple V-rings or U-cups with O-rings of nitrile rubber.
b. Internal surfaces of valve body epoxy lined (except seat).
c. Operators:
1) 3-Inch and 4-Inch Valves: Wrench lever manual.
2) 6-Inch through 12-Inch Valves: Totally enclosed, geared, manual operator, with handwheel, 2-inch nut, or chain wheel.
d. Manufacturers and Products:
1) Pratt; Ballcentric.
2) DeZurik; Style PEC.
3) Milliken; Millcentric Series 600.

6. Type V420 Nonlubricated Plug Valve 2 Inches and Smaller:
   a. Ductile iron or carbon steel body, Type 316 stainless steel plug with straight-way rectangular ports, Teflon sleeves, screwed ends, wrench operator.
   b. Class: 150.
   c. Rating: 275 psi WOG.
   d. Manufacturers and Products:
      1) Duriron Co.; Figure No. G432.
      2) Tufline; Figure 066.
7. Type V422 Nonlubricated Plug Valve 2-1/2 Inches to 14 Inches:
   a. Ductile iron or carbon steel body, Type 316 stainless steel plug with straight-way rectangular ports, Teflon sleeves, flanged ends.
   b. Class: 150.
   c. Rating: 275 psi WOG.
   d. Operator:
      1) 4 Inches and Smaller Valve: Wrench type.
      2) 6 Inches and Larger Valve: Enclosed gear type.
   e. Manufacturers and Products:
      1) Duriron Co.; Figure No. G411
      2) Tufline; Figure 067.
8. Type V462 Gauge Cock 1/8 Inch to 1/4 Inch:
   a. 1/4-inch bronze body, hexagon end pattern, tee head, male ends, rated 125-pound SWP.
   b. Manufacturer and Product: United Brass Works; Figure 973.
9. Type V470 Combination Balancing and Shutoff Valve 2-1/2 Inches and Smaller for Heating, Chilled, and Cooling Water Service:
   a. Nonlubricated plug valve, cast-iron body, NPT threaded ends, cast-iron plug with FKM resilient plug facing, PTFE packing, dual stainless steel bearings, PTFE thrust seal, adjustable memory stop, rated 175 psi CWP, lever operator, upstream and downstream 1/8-inch flow taps with air valve fittings and sealing caps.
   b. Manufacturer and Product: DeZurik; Style PEC.
10. Type V472 Combination Balancing and Shutoff Valve 3 Inches to 24 Inches for Heating, Chilled, and Cooling Water Service:
   a. Nonlubricated plug valve, cast-iron body, ASME B16.1 Class 125 flanged ends, cast-iron plug with FKMresilient plug facing, PTFE packing, dual stainless steel bearings, PTFE thrust seal, adjustable memory stop, rated 150 psi CWP minimum, lever operator for 3-inch and 4-inch valves, totally enclosed and sealed heavy-duty gear operator for 6-inch and larger valves, upstream and downstream 1/8-inch flow taps with air valve fittings and sealing caps.
   b. Manufacturer and Product: DeZurik; Style PEC.

D. Butterfly Valves:

1. General:
   a. In full compliance with AWWA C504 and following requirements:
      1) Suitable for throttling operations and infrequent operation after periods of inactivity.
      2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
      3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
      4) No travel stops for disc on interior of body.
      5) Self-adjusting V-type or O-ring shaft seals.
      6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
      7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
      8) Buried service operators shall withstand 450 foot-pounds of input torque at fully open and fully closed positions.
      9) Provide linings and coatings per AWWA, unless otherwise indicated on Drawings or specified herein.
      10) Valves to be in full compliance with NSF/ANSI 61.
   b. Non-AWWA butterfly valves to meet the following actuator requirements:
      1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on Drawings or specified herein.
2. Type V500 Butterfly Valve Water Works Service 3 Inches to 72 Inches:
   a. AWWA C504, Class 150B.
   b. Short body type, flanged ends.
   c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, Buna-N rubber seat bonded or molded in body only, and stainless steel seating surface.
   d. Manufacturers and Products:
      1) Pratt; Model 2FII or Triton XR-70.
      2) DeZurik; AWWA Valve.
3. Type V501 Butterfly Valve Water Works Service 30 Inches to 72 Inches:
   a. AWWA C504, Class **[A: 75] [B: 25] [C: A] [D: B]**.
   b. Short body type, flanged ends.

c. Cast-iron body, ductile iron disc with Type 316 stainless steel seating edge, Type **[E: 304] [F: 316]** stainless steel shafts, **[G: Buna-N] [H: EPDM] [I:]** rubber seat **[J: bonded or molded in body only]**.
d. **[K: Provide epoxy lining [L: and coating] in compliance with AWWA C550.]**
e. Manufacturers and Products:
1) Pratt; Model Triton XR-70.
2) DeZurik; AWWA Valve.

4. Type V502 Butterfly Valve General Service 3 Inches to 20 Inches:
a. AWWA C504, Class 150B.
b. Wafer style type.
c. Buna-N rubber seat.

5. Type V504 Butterfly Valve General Service 4 Inches to 48 Inches:
a. AWWA C504, Class 150B.
b. Mechanical joint end type.
c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, Buna-N rubber seatbonded or molded in body only, and stainless steel seating surface.
d. Manufacturers and Products:
1) Pratt; Groundhog.
2) DeZurik; Buried AWWA Valve.

6. Type V506 Butterfly Valve High Pressure Service 4 Inches to 48 Inches:
a. AWWA C504, Class 250B.
b. Short body type, Class 250 flanged ends.
c. Cast or ductile iron body, cast or ductile iron disc with Type 316 stainless steel disc edge, ASTM A564/A564M Type 630 Condition H-1100/1150 or Type 316 stainless steel shaft, Buna-N rubber seat bonded or molded in body only, self-adjusting V-type multi-ring seals.
d. Manufacturers and Products:
1) Pratt; Triton HP-250.
2) DeZurik; AWWA Flanged Class 250.
3) Mueller; Lineseal XP Class 250.

7. Type V507 Butterfly Valve High Pressure Service 4 Inches to 48 Inches:
a. AWWA C504, Class 250B.
b. Mechanical joint ends.
c. Cast or ductile iron body, cast or ductile iron disc with Type 316 stainless steel disc edge, ASTM A564/A564M Type 630 Condition H-1100/1150 or Type 316 stainless steel shaft, Buna-N rubber seat bonded or molded in body only, self-adjusting V-type multi-ring seals.

d. Manufacturers and Products:
   1) Pratt; Triton HP-250.
   2) DeZurik; AWWA Mechanical Joint Class 250.
   3) Mueller; Lineseal XP250.

8. Type V510 Lug Style Butterfly Valve, Resilient Seated, 2 Inches to 20 Inches for Low Pressure Process Air Service:
   a. Lug style cast-iron body, aluminum bronze discs, Type 316 stainless steel one-piece stem, self-lubricating sleeve type bushings, EPDM replaceable resilient seat suitable for operating temperatures up to 250 degrees F, 150 psi working pressure rating, bubble-tight at 50 psi differential pressure, valve body to fit between ASME B16.1 Class 125/150 flanges.
   b. Manufacturers and Products:
      1) Bray Controls; Series 31.
      2) Tyco/Keystone; Model AR2.
9. Type V511 Flanged Style Butterfly Valve, Resilient Seated, 24 Inches to 48 Inches for Low Pressure Process Air Service:
   a. Flanged style cast-iron body, aluminum bronze discs, Type 304 stainless steel one-piece stem, self-lubricating bronze sleeve type bearing, EPDM replaceable resilient seat suitable for operating temperatures up to 250 degrees F, 150 psi working pressure, rating, bubble-tight at 50 psi differential pressure, externally adjustable bronze packing gland with Buna-N packing, valve body to fit between ASME B16.1 Class 125/150 flanges.
   b. Manufacturers and Products:
      1) Bray Controls; Series 35.
      2) Tyco/Keystone; Figure 106.
10. Type V512 Lug Butterfly Valve 2 Inches to 20 Inches for Digester Gas:
   a. Lug style, two-piece cast-iron body, one-piece Type 316 stainless steel thin-profile disc and stem, heavy-duty stem bushing, NBR stem seal, FKM (Viton) replaceable resilient seat, 50 psi pressure bi-directional bubble-tight rating, suitable for temperatures up to 250 degrees F, valve body to fit between ASME B16.1 Class 125/150 flanges. Supply reduced disc diameter, if available.
   b. Manufacturers and Products:
      1) Bray Controls; Model 21.
      2) Tyco/Keystone; Model 920.
11. Type V513 Butterfly Valve 2 Inches to 20 Inches:
   a. Lug style, ductile iron body, ductile iron disc, Type 316 or Type 18-8 stainless steel one-piece stem, Buna-N replaceable resilient seat, heavy-duty self-lubricating sleeve type bushings, NBR stem seal, 150 psi working pressure rating, valve body to fit between ASME B16.1 Class 125/150 flanges.

b. Manufacturers and Products:
   1) Bray Controls; Series 30/31.
   2) Tyco/Keystone; Model AR1/AR2.
   3) Crane/Centerline; Series 200.

12. Type V520 Solid Polyvinyl Chloride Butterfly Valve 1-1/2 Inches to 8 Inches:
    a. Wafer body type, pressure rated 150 psi at 70 degrees F CWP, solid ASTM D1784, Type I, Grade 1, PVC body and contoured PVC or polypropylene valve disc, stainless steel valve stem, Viton seat, lever operator.
    b. Manufacturers and Products:
       1) ASAHI/America; Type 57.
       2) Spears.
13. Type V530 Butterfly Valve 4 Inches to 20 Inches for Fire Protection Service:
    a. UL Listed and FM Approved, flanged style, AWWA C504 Class 150B valve with cast-iron body, aluminum-bronze disc, stainless steel stem, EPDM seat, geared operator with highly visible position indicator and detachable crank handle.
    b. For buried service, provide post indicating assembly with detachable crank handle.
    c. Manufacturer and Product: Pratt; IBV, PIVA.

E. Check and Flap Valves:

1. Type V600 Check Valve 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded or soldered ends, swing type replaceable bronze disc, rated 125-pound SWP, 200-pound WOG.
   b. Manufacturers and Products:
      1) Stockham; Figure B-319, threaded ends.
      2) Milwaukee; Figure 509, threaded ends.
      3) Stockham; Figure B-309, soldered ends.
      4) Milwaukee; Figure 1509, soldered ends.
2. Type V602 Check Valve 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded ends, swing type replaceable Teflon disc and bronze disc holder, rated 150-pound SWP, 300-pound WOG.
   b. Manufacturers and Products:
      1) Walworth; Figure 3412.
      2) Milwaukee; Figure 510.
3. Type V604 Check Valve 2-1/2 Inches to 12 Inches:
   a. Flanged end, cast-iron body, bronze mounted swing type, solid bronze or cast-iron disc, bronze seat ring, rated 125-pound SWG, 200-pound WOG.

b. Manufacturers and Products:
   1) Stockham G-931; List 37, Clearway check valve.
   2) Crane Co.; Cat. No. 373.

4. Type V606 Check Valve 2 Inches to 12 Inches:
   a. Flanged end, cast-iron body, bronze mounted swing type, solid bronze or cast-iron disc, bronze seat ring, outside lever and weight, rated 125-pound SWP, 200-pound WOG.
   b. Manufacturers and Products:
      1) Stockham; G-931.
      2) Crane Co.; Cat. No. 383.
5. Type V608 Swing Check Valve 2 Inches to 24 Inches:
   a. AWWA C508, 125-pound flanged ends, cast-iron body, bronze body seat, bronze mounted cast-iron clapper with bronze seat, stainless steel hinge shaft.
   b. Valves, 2 inches through 12 inches rated 175-pound WWP and 14 inches through 24 inches rated 150-pound WWP. Valves to be **[C: plain fitted] [D: fitted with adjustable outside lever and weight] [E: fitted with adjustable outside lever and spring] [F: fitted with dual adjustable outside levers and springs]**. Increasing-pattern body valve may be used where increased outlet piping size is shown.
   c. Manufacturers and Products:
      1) M&H Valve; Style 59, 159, or 259.
      2) Mueller Co.; No. A-2600 Series.
6. Type V610 Swing Check Valve 2-1/2 Inches to 12 Inches for Fire Protection Service:
   a. UL Listed, FM Approved, iron body, bronze-mounted, rated 175 pounds WOG, self-adjusting bronze disc, ends ASME B16.1 flanged, with a 1-inch NPT tapped and plugged boss.
   b. Manufacturers and Products:
      1) Kennedy; Figure 126.
      2) Mueller; A-2120-6.
7. Type V612 Double Disc Swing Check Valve 2 Inches to 48 Inches:
   a. Wafer style, spring loaded, cast-iron body, aluminum-bronze or ductile iron discs, Buna-Nresilient seats, and Type 316 stainless steel spring, hinge pin, and stop pin.
   b. Valves 2 inches through 12 inches rated 200 psi nonshock working pressure and valves 14 inches through 48 inches rated 150 psi nonshock working pressure.
   c. Manufacturers and Products:
      1) APCO; Series 9000.
      2) Val-Matic; Dual Disc.
      3) Crane/Stockham; WG-970.
      4) Tyco; Gulf MB Series.

8. Type V615 Slanting Disc Check Valve 2 Inches to 60 Inches:
    a. Slanting or tilting disc design, off-center pivot, body ductile iron two-piece design, bronze seat on 55 degree angle, disc bronze or ductile iron, pivot pin and bushing Type 304 stainless steel, Class 250, 300 psi rating, Class 250 flange drilling, flat face, valve disc position indicator.
    b. Manufacturers and Products:
        1) APCO; Series 800.
        2) Val-Matic; Series 9700.
9. Type V616 Slanting Disc Check Valve 2 Inches to 36 Inches:
    a. Off-center pivoting disc design, wafer style, cast-iron body, ductile iron discs, Type 316 stainless steel pivot pin, spring pin, and bushing, Buna-N disc seal, Type 316 stainless steel or Monel spring, Class 250.
    b. Manufacturers and Products: Daniel Flow Products; Chexter 1600 Series, Type D.
10. Type V620 Silent Check Valve 2 Inches to 10 Inches:
    a. Wafer style, iron body, center guided valve, bronze trim, Buna-N seat, stainless steel springs, rated 150-pound WOG.
    b. Manufacturers and Products:
        1) Mueller; Steam Specialty 91AP.
        2) APCO; Series 300.
11. Type V630 PVC Ball Check Valve 4 Inches and Smaller:
    a. ASTM D1784, Type I, Grade 1 polyvinyl chloride body, dual union socket weld ends, rated 150 psi at 73 degrees F, and Viton seat and seal.
    b. Manufacturers and Products:
        1) Nibco; Chemtrol Tru Union.
        2) ASAHI/America.
        3) Spears; True Union.
12. Type V631 CPVC Ball Check Valve 4 Inches and Smaller:
    a. ASTM D1784 Cell Class 23477B CPVC body, single or dual union socket weld ends, rated 150 psi at 73 degrees F, 110 psi at 140 degrees F, Viton seat and seal.
    b. Manufacturers and Products:
        1) Nibco; Chemtrol Tru Union.
        2) ASAHI/America.
        3) Spears; True Union.
13. Type V632 Ball Check Valve 3 Inches and Larger:
    a. Flanged end, iron body valve with cleanout and floating type hollow steel ball, vulcanized nitrile rubber exterior, flanges ASME B16.1, Class 125, rated 150-pound working pressure, suitable for vertical up or horizontal flow.

b. Manufacturers and Products:
   1) FLYGT Corp;
   2) Flomatic Corp.;
   3) Golden Anderson.

14. Type V634 Rubber Flapper Check Valve 2 Inches to 24 Inches:
    a. Iron body, ASME B16.1, Class 125 flanges, steel-reinforced Buna-N flapper raised seating ring, rated 150-pound CWP.
    b. Manufacturers and Products:
       1) APCO; Series 100.
       2) Val-Matic; “Swingflex.”
15. Type V640 Double Check Valve Backflow Prevention Assembly 3/4 Inch to 10 Inches:
    a. Two resilient seated check valves, two nonrising stem resilient-seated isolation valves, test cocks, in accordance with AWWA C510, rated 175 psi maximum working pressure, meets requirements of USC Foundation For Cross-Connection Control and Hydraulic Research.
    b. Manufacturers and Products:
       1) FEBCO; Model 850.
       2) Danfoss Flomatic; Model DCVE/DCV.
       3) Watts; Series 007/709.
16. Type V642 Reduced-Pressure Principle Backflow Prevention Assembly 3/4 Inch to 10 Inches:
    a. Two resilient seated check valves with an independent relief valve between the valves, two nonrising stem resilient-seated isolation valves, test cocks, in accordance with AWWA C511, rated 175 psi maximum working pressure, meets requirements of USC Foundation For Cross-Connection Control and Hydraulic Research.
    b. Manufacturers and Products:
       1) FEBCO; Model 860.
       2) Danfoss Flomatic; Model RPZE/RPZ.
       3) Watts; Series 009/909.
17. Type V644 Wet Pipe Alarm Valve:
    a. Valve and Trim:
       1) UL Listed and FM Approved as a complete unit, rated 175 psi working pressure, 125-pound ASME B16.1 flanged inlet andoutlet.
       2) Supplied with full trim for position as shown on Drawings including, but not necessarily limited to, water pressure gauges (with test valves), alarm test valve, mechanical sprinkler alarm bell connection (with strainer), pressure switch for electric alarm signal, retarding chamber, alarm and retard chamber drains, and main drain.

3) Provide with additional valves, piping, and fittings as required for complete and fully functioning arrangement.

b. Manufacturers and Products:
1) Reliable Automatic Sprinkler Co., Inc.; Model E Alarm Valve.
2) Tyco/Central; Model.

18. Type V652 Check Valve 2 Inches and Smaller for Fuel Oil Service:
a. Forged steel, lift-check type integral seat, stainless steel disc, screwed ends, rated 800 psi at 850 degrees F.
b. Manufacturers and Products:
1) Smith; C80.
2) R-P&C; F90.

19. Type V654 Check Valve 2 Inches and Smaller for Heating, Chilled, and Cooling Service:
a. All-bronze type silent check valve, screwed ends, rated 200-pound WOG.
b. Manufacturers and Products:
1) Mueller; Steam Specialty No. 203-BP.
2) Metraflex;

20. Type V690 Flap Gate 6 Inches to 96 Inches:
a. Cast-iron body and cover, bronze-mounted, flanged frame type, dual pivot-point hinge arms, hinge arms bronze, hinge pins Type 304 stainless steel, seat bronze and impacted into grooves in body and cover flap, lubrication fittings for each pivot, upper and lower pivot adjustment.
b. Manufacturers and Products:
1) Rodney Hunt Co.; Series FV-AC or FV-AR.
2) Hydro Gate; Model 50C or 50.

21. Type V692 Flap Valve 4 Inches to 30 Inches:
a. Flange style frame, cast-iron body, bronze seats on body and cover, bronze hinge pins.
b. Manufacturers and Products:
1) M&H Valve; Style 47-02.
2) Clow Valve; No. F-3012.

22. Type V694 Check Valve 1 Inch to 48 Inches:
a. Elastomer type flanged or slip-on as shown on Drawings, round entry area to match pipe, contoured duckbilled shaped exit, flat bottom and off-set bill design, curved bill for 18 inches and larger, valve open with approximately 2 inches of line pressure and return to CLOSED position under zero flow condition, rated for 50 psi minimum operating pressure; flanges steel backing flange type, drilled to ASME B16.1, Class 125, plain-end valve attached with two Type 316 stainless steel adjustable bands, elastomer nylon-reinforced Buna-N.
b. Manufacturer and Product: Red Valve Co.; Tideflex Check Valve Series TF-1 or 35-1.

F. Self-Regulated Automatic Valves:

1. Type V720 PVC Pressure Relief, By-Pass Relief, Back-Pressure Regulator, Back-Pressure, Anti-Siphon Valve 1/2 Inch to 2 Inches:
   a. Direct acting diaphragm, spring controlled, in-line pattern, NPT threaded inlet and outlet, 150 psi design pressure.
   b. PVC body, Teflon or Viton diaphragm, PVC or Teflon piston, high-density polyethylene or stainless steel adjusting bolt and locknut, stainless steel or coated steel spring, stainless steel fasteners.
   c. Designed to open when upstream pressure reaches setpoint; set pressure adjustable from 10 psi to 100 psi, minimum. **[A: Factory set pressure setting at [B: 25] [C:] psi for back-pressure and anti-siphon valves, [D: 10] [E:] psi for pressure relief valves, [F: 100] [G:] psi for bypass relief valves, and [H: 50] [I:] psi for back-pressure regulator valves.]**
   d. Manufacturers and Products:
      1) Plast-O-Matic; Series RVDT.
      2) Griffco; Series BPV.
      3) Primary Fluid Systems; TOP Valve.
2. Type V722 PVC Pressure Regulating Valve, 1/2 Inch to 1-1/2 Inches:
   a. Diaphragm operated assembly, spring controlled, in-line pattern, NPT threaded inlet and outlet, 150 psi design pressure.
   b. PVC body, Viton seals and diaphragm, coated stainless steel spring, stainless steel adjusting bolt, locknut, and fasteners.
   c. Designed to regulate downstream pressure closing when pressure reaches setpoint; set pressure adjustable from 5 psi to 50 psi. **[A: Factory set pressure setting at [B:] psi.]**
   d. Manufacturers and Products:
      1) Plast-O-Matic, Series PR.
      2) Hayward; Pressure Regulator.
3. Type V725 Automatic Degassing Valve, 1/2 Inch to 3/4 Inch:
   a. PVC or CPVC construction with Viton seals, NPT threaded inlet and outlet, float designed to automatically vent gases, **[A: 100] [B: 150]** psi design pressure.
   b. Manufacturers and Products:
      1) **[C: Plast-O-Matic; Series DGV]**.
      2) Primary Fluid Systems, Inc.; Accu-Vent.
4. Type V730 Pressure-Relief Valve 2 Inches and Smaller:
   a. Direct diaphragm, spring controlled, **[A: cast-iron] [B:]** body, spring case, **[C: nitrile] [D:]** seat **[E: neoprene] [F:]** diaphragm, stainless steel valve stem, NPT threaded ends, 200 psi rated.
   b. Opens when upstream pressure reaches a maximum set point.

c. Size/Rating: **[G:]** inch, maximum of **[H:]** gpm, with inlet pressure of **[I:]** psig. Outlet pressure set at **[J:]** psig. **[K: As shown in Valve Schedule.]**
d. Manufacturer and Product: Fisher; 98 Series.

5. Type V740 Air and Vacuum Valve 1/2 Inch to 16 Inches:
   a. 1/2-inch through 3-inch NPT inlets and outlets, 4-inch and larger ASME B16.1 Class **125** flanged inlet with plain outlet and protective hood.
   b. Rated **150** psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512.
   c. Manufacturers and Products:
      1) APCO Valve and Primer Corp.; Series 140 or 150.
      2) Val-Matic Valve; Series 100.
6. Type V741 Air and Vacuum Valve 4 Inches to 16 Inches with Anti-Slam Device:
   a. Equipped with anti-slam device to throttle flow of water into air valve. Design anti-slam device to permit full, unrestricted flow of air into and out of air valve but reduce flow area for water to approximately 10 percent.
   b. Rated 150 psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512, ASME B16.1 Class 125 flanged inlet and plain outlet with protective hood.
   c. Manufacturers and Products:
      1) APCO Valve and Primer Corp.; Series 1900.
      2) Val-Matic Valve; Series 1200/100.
7. Type V742 Air and Vacuum Valve 1/2 Inch to 16 Inches for Vertical Turbine Service:
   a. Equip 1/2 inch through 3 inches with stainless steel diffuser screen to break up solid water column before coming in contact with float, manufacturer's standard double acting throttling device in outlet for throttling, NPT threaded inlet and outlet.
   b. Equip 4 inches and larger with anti-slam device to throttle flow of water into air valve. Design anti-slam device to permit full, unrestricted flow of air into and out of air valve, but reduce flow area for water to approximately 10 percent. ASME B16.1 Class 125 flanged inlet and NPT threaded outlet.
   c. Rated 150 psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512.
   d. Manufacturers and Products:
      1) APCO Valve and Primer Corp.; Series 141DAT to 146DAT or Series 1904 to 1916.
      2) Val-Matic Valve; Series 100WS to 116WS.

8. Type V744 Air Release Valve 1/2 Inch to 2 Inches:
    a. Suitable for water service, automatically exhaust small amounts of entrained air that accumulates in a system. In CLOSED position, seat against resilient seat to prevent water leakage.
    b. Rated 150 psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, NPT threaded inlet and outlet, built and tested to AWWA C512Manufacturers and Products:
        1) APCO Valve and Primer Corp.; Series 50, 200, and 200A.
        2) Val-Matic Valve; Series 15A to 45.6.
9. Type V745 Air Release Valve 1/2 Inch to 1 Inch:
    a. Suitable for water service, automatically exhaust small amounts of entrained air that accumulates in system. In CLOSED position, seat against resilient seat to prevent water leakage.
    b. Rated 230-psi working pressure, cast-iron body with brass base, foamed polypropylene float, EPDM rolling seal, Buna-N O-ring, NPT threaded inlet.
    c. Manufacturer and Product: ARI Valves; S-050, S-050-C.
10. Type V746 Combination Air Release Valve 1 Inch to 16 Inches:
    a. Suitable for water service, combines operating features of air and vacuum valve and air release valve. Air and vacuum portion to automatically exhaust air during filling of system and allow air to re-enter during draining or when vacuum occurs. Air release portion to automatically exhaust entrained air that accumulates in system.
    b. Valve single body or dual body, air release valve mounted on air and vacuum valve, isolation valve mounted between the dual valves. 1-inch through 3-inch valves with NPT threaded inlet and outlet, 4-inch and larger valves with ASME B16.1 Class 125 flanged inlet and cover outlet.
    c. Rated 150 psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512.
    d. Manufacturers and Products:
        1) APCO Valve and Primer Corp.; Series 143C to 147C or 1804 to 1816.
        2) Val-Matic Valve; Series 201C to 203C or 104/22 to 116/38.
11. Type V750 Sewage Air and Vacuum Valve 2 Inches to 14 Inches:
    a. Suitable for sewage service; automatically exhausts air during system filling and allows air to re-enter during draining or when vacuum occurs.
    b. Rated working pressure of 150 psi, 1-inch through 3-inch valves with NPT threaded inlet and outlet, 4-inch and larger valves with ASME B16.1 Class 125 flanged inlet and threaded cover outlet, built and tested to AWWA C512.

c. Materials: Cast-iron or ductile iron body and cover, concave or skirted stainless steel float and trim, Buna-N seat.
d. Manufacturers and Products:
   1) APCO Valve and Primer Corp.; Series 401 SAVV to 414 SAVV.
   2) Val-Matic Valve; Series 301 to 306.

12. Type V752 Sewage Air Release Valve 2 Inches to 4 Inches:
    a. Suitable for sewage service; automatically exhausts entrained air that accumulates in a system.
    b. Rated working pressure of 150 psi, operating pressure of, built and tested to AWWA C512.
    c. Materials: Cast-iron or ductile iron body and cover with NPT threaded inlet and **[B: 1/2-inch] [C: 1-inch]** NPT threaded outlet, concave or skirted stainless steel float and trim; Buna-N resilient seat.
    d. Manufacturers and Products:
       1) APCO Valve and Primer Corp.; Series 400 SARV or 450 SARV.
       2) Val-Matic Valve; Series 48 or 49.
13. Type V754 Sewage Combination Air Valve 2 Inches to 6 Inches:
    a. Suitable for sewage service; combines operating functions of air and vacuum valve and an air release valve. Air and vacuum portion shall automatically exhaust air during filling of a system and allow air to re-enter during draining or when a vacuum occurs. Air release portion to automatically exhaust entrained air that accumulates in system. Single body unit with air and vacuum valve and an air release valve in a single housing.
    b. Rated working pressure of 150 psi; built and tested to AWWA C512.
    c. Materials: Cast-iron or ductile iron body and covers, NTP threaded inlet and outlet, with concave or skirted stainless steel float and trim.
    d. Manufacturers and Products:
       1) APCO Valve and Primer Corp.; Series 440 SCAV.
       2) Val-Matic Valve; Series 800.
14. Type V756 Sewage Combination Air and Vacuum Valve 6 Inches to 14 Inches:
    a. Suitable for sewage service; combines operating functions of air and vacuum valve and an air release valve using separate valves connected together. Air and vacuum valve shall automatically exhaust large quantities of air during system filling and allow air to re-enter during draining or when a vacuum occurs. Air release valve to automatically exhaust small quantities of entrained air that accumulates in system.

b. Rated working pressure of 150 psi, operating pressure of 300 psi**.**
c. Materials: Cast-Iron or Ductile Iron Body:
1) Air and Vacuum Valve:
a) Upper and lower concave or skirted stainless steel float and trim.
b) Inlet Flanges: ASME B16.1 Class 125 pound.
c) Outlet: Flanged.
d) Seat: Buna-N.
2) Air Release Valve: 2-inch NPT threaded inlet and 1/2-inch NPT threaded outlet; Buna-N seat.
d. Provide with all-bronze blow-off and flushing gate valves for each valve, all-bronze isolation gate valve between air and vacuum valve and air release valve; 5-foot rubber hose with quick disconnect couplings.
e. Manufacturer and Product: APCO Valve and Primer Corp.; Series 400C.

15. Type V757 Sewage Rolling Seal Combination Air Valve 2 Inches to 8 Inches:
a. Designed for sewage service, uses rolling seal to allow smaller and larger amounts of air to automatically exhaust under pressure and air to enter when a vacuum occurs in a single valve body. Body designed to allow sewage solids to flow out of valve.
b. Stainless steel funnel shaped body with ASME B16.1 Class 150 flanged inlet and access flanges, reinforced nylon combination air and vacuum valve assembly and polypropylene discharge elbow, 250-psi working pressure, all-bronze drain/flush valve, flushing connection.
c. Foamed polypropylene float, EPDM rubber rolling seal mechanism with reinforced nylon plug, plug cover, and clamping stem, Buna-N O-ring.
d. Manufacturer and Product: ARI Valves; D-020.

G. Miscellaneous Valves:

1. Type V905 Pinch Valve 1 Inch to 12 Inches:
a. Cast-iron fully enclosed body, epoxy lined and coated, ASME B16.1 Class 125 flanged ends, one-piece molded Buna-N elastomer tube, full-port design, 90 psi minimum working pressure, double-acting upper and lower pinch bars that close on centerline, stainless steel stem, handwheel operator, position indicator, geared operator for valves 6 inches and larger.
b. Manufacturers and Products:
1) Red Valve Co.; Series 75.
2) RF Technologies, Inc.; RF Valve.

2. Type V910 Telescoping Scum Collection Valve:
   a. Rack and pinion type with offset floor stand and cast-iron offset floor stem incorporating rack guides, pinion, and handwheel supports. Rack and pinion and connecting rods Type 304 stainless steel, slip pipe brass with flat weir-crest skimming funnel, cast-iron pipe companion flange, O-ring seal and gasket for connection to discharge pipe. Skimming funnel minimum top diameter of 8 inches.
   b. Valve, 4 inches nominal and continuously adjustable from a high point of 1.5 feet below bottom of floor stand to a low point 5.50 feet below bottom of floor stand.
   c. Anchor Bolts: Type 316 stainless steel.
   d. Manufacturers and Products:
      1) Link-Belt Division of FMC Corp.;
      2) Envirex Division of Rexnord Corp.;
3. Type V915 Mud Valve 4 Inches to 24 Inches:
   a. Cast-iron frame, yoke, and gate; heavy-duty 125-pound flange style, bronze seat, Buna-N seal, nonrising stem, bronze stem and stem nut, 2-inch square operating nut, cast-iron floor box.
   b. Manufacturers:
      1) Troy Valve.
      2) Trumbull Industries, Inc.
      3) Clow Valve Company.
4. Type V920 Hydrostatic Pressure Relief Valve, Floor Type 4 Inches:
   a. Floor type, cast-iron body, grate, and cover, removable cover and strainer, body with integral seep ring, body length as shown on Drawings, neoprene rubber cover seat, epoxy body seat.
   b. Manufacturers and Products:
      1) M&H Valve; Style 147, F-1493.
      2) Clow Valve; Figure F-1493.
5. Type V921 Hydrostatic Pressure Relief Valve, Wall Type 4 Inches:
   a. Wall type, flange style frame, cast-iron body and cover, bronze seat body, resilient rubber seat on cover, bronze hinge pins, cast-iron wall pipe with integral seep ring and strainer, length as shown on Drawings.
   b. Manufacturers and Products:
      1) M&H Valve; Style 147, F-1494/F-1496.
      2) Clow Valve; Figure F-1494/F-1496.
6. Type V940 Solenoid Valve 1/4 Inch to 2 Inches:
   a. Two-way internal pilot operated diaphragm type, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, NEMA insulation Class F, 120 volts ac, 60-Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4 unless otherwise indicated. Size and normal position (when de-energized) as indicated onP&ID.

b. Minimum operating pressure differential no greater than 5 psig, maximum operating pressure differential not less than 125 psig.
c. Manufacturers and Products:
1) ASCO;
2) Skinner;

7. Type V950 Manual In-Line Lockout/Tagout Valve 1/4 Inch to 1-1/4 Inches for Air Service:
a. Manual in-line, three-port, heavy-duty cast aluminum body, NPT threaded ports, tee-handle, aluminum spool, stainless steel spring, nitrile seals, suitable for air pressures 0 psig to 250 psig. Safety yellow body with contrasting black, red or blue handle.
b. Lockout/tagout valve for compliance to OSHA 29 CFR Part 1910.147. Full flow in open position, exhausts downstream air in closed position, lockable in closed position.
c. Complete with NPT male threaded aluminum exhaust silencer with internal mesh element, lockout hasp.
d. Manufacturers and Products:
1) Norgren; In-Line Lockout Valve Series C00.
2) Parker Pneumatic; LV Series.
3) Ross Controls; L-O-X Valve.

8. Type V951 Manual Soft-Start In-Line Lockout/Tagout Valve 1/4 Inch to 1-1/4 Inches for Air Service:
a. Manual in-line, three-port, single unit type, heavy-duty cast aluminum body, NPT threaded ports, tee-handle, aluminum spool, stainless steel spring, nitrile seals, suitable for air pressures 30 psig to 150 psig. Safety yellow body with contrasting black, red or blue handle.
b. Lockout/tagout valve with soft start feature for compliance to OSHA 29 CFR Part 1910.147. Full flow in open position, exhausts downstream air in closed position, lockable in closed position, soft-start feature to allow gradual air pressure buildup.
c. Complete with NPT male threaded aluminum exhaust silencer with internal mesh element, lockout hasp.
d. Manufacturers and Products:
1) Parker Pneumatic; EZ Series.
2) Ross Controls; L-O-X/EEZ-ON Valve.

2.06 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.

b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
c. Operator self-locking type or equipped with self-locking device.
d. Position indicator on quarter-turn valves.
e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.

2. Exposed Operator:
   a. Galvanized and painted handwheel.
   b. Cranks on gear type operator.
   c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
   d. Valve handles to take a padlock, and wheels a chain and padlock.
3. Buried Operator:
   a. Buried service operators on valves larger than 2-1/2 inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by forked key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
   b. Buried service operators to be grease packed and gasketed to withstand submersion in water to 20 feet minimum.
   c. Buried valves shall have extension stems, bonnets, and valve boxes.

B. Electric Operators, 120 Volts:

1. General:
   a. Unit shall be low profile to reduce amount of required space and weigh 15 pounds or less.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of the valve.
   c. Provide operator mounting bracket to mount operator to valve providing minimal torque to piping system when operating.
2. Operator Operation, General:
   a. Suitable for full 90-degree rotation of quarter-turn valves.
   b. Manually override handwheel.
   c. Mechanical valve position indication.

3. Electronic Control:
    a. Torque Limiting Switches: Two single pole, double throw mechanical switches. Switches operate at any point in valve travel.
    b. Jammed-valve detection and protection.
    c. Motor over-temperature detection and protection.
    d. Travel limit switches, single pole double throw.
4. Open-Close (O/C) Service:
    a. Duty cycle for intermittent ON-OFF operation shall be 25 percent.
    b. Operator shall power to OPEN and power to CLOSE.
    c. Local Indication and Control:
        1) Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.
        2) Integral OPENED and CLOSED indication lights.
        3) Integral LOCAL-OFF-REMOTE (L-O-R).
        4) Integral OPEN maintained switch which causes the valve to stroke full OPENED, even if OPEN switch is released, while L-O-R switch is in LOCAL.
        5) Integral CLOSE maintained switch which causes valve to stroke full CLOSED, even if CLOSED switch is released, while L-O-R switch is in LOCAL.
    d. Remote Indication and Control:
        1) Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.
        2) Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.
        3) Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.
    e. Modulating (M) Service:
        1) Operator rated for continuous duty with servo shall be rated for 100 percent modulating operation.
        2) Operator shall modulate based on an externally applied 4 mA to 20 mA dc signal.
        3) Operator shall be equipped with an electronic servo module for valve modulation.
            a) Module shall provide serial communications with provided cable for setup of valve operation.
    f. Local Indication and Control:
        1) Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.
        2) Integral OPENED and CLOSED indication lights.
        3) Integral LOCAL-OFF-REMOTE (L-O-R).

4) Integral OPEN momentary switch which causes valve to stroke towards OPENED, as long as OPEN switch is held, while L-O-R switch is in LOCAL.
5) Integral CLOSE momentary switch which causes valve to stroke towards CLOSED, as long as CLOSED switch is held, while L-O-R switch is in LOCAL.
6) Position valve proportionally 0 to 100 percent OPEN with external 4 mA to 20 mA dc signal while in REMOTE.

g. Remote Indication and Control:
1) Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.
2) Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.
3) Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.
4) Current Position Transmitter, 4 mA to 20 mA dc signal in proportion to 0 percent to 100 percent OPENED, with 0.5 percent accuracy and 0.5 percent repeatability, capable of driving a 750-ohm load, for connection to and monitoring by Plant Control System.

5. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.
6. Manufacturer and Product: Rotork;

C. Electric Motor Actuators, 480 Volts:

1. General:
a. Comply with latest version of AWWA C542.
b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
c. Controls integral with actuator and fully equipped as specified in AWWA C542.
d. Stem protection for rising stem valves.

2. Actuator Operation—General:
a. Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.
b. Manual override handwheel.
c. Valve position indication.
d. Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in Electric Actuated Valve Schedule.

e. Nonintrusive Electronic Control: Local controls, diagnostics, and calibration, including limit and torque settings, shall be accomplished nonintrusively. Electronic valve position display with capability to show continuous torque output. If applicable, provide two hand-held configuration units for every 10 actuators provided, two minimum.

3. Open-Close(O/C)/Throttling(T) Service:
   a. Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.
   b. Actuator suitable for throttling operation of valve at intermediate positions.
   c. LOCAL-OFF-REMOTE Selector Switch, padlockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
      2) Remote OPEN-STOP-CLOSE momentary control dry contact inputs in REMOTE position. Integral seal-in circuits for remote OPEN and CLOSE commands; valve travel stops when remote STOP contact opens.
      3) Auxiliary contact that closes in REMOTE position.
   d. OPEN and CLOSED indicating lights.
   e. Integral reversing motor starter with built-in overload protection.
4. Modulating (M) Service:
   a. Size actuators for continuous modulating duty.
   b. Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.
   c. HAND-OFF-AUTO (Local-Off-Remote) Selector Switch, padlockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in HAND (Local) position.
      2) 4 mA to 20 mA dc input signal to control valve in AUTO (Remote) position.
      3) Auxiliary contact that closes in AUTO (Remote) position.
   d. OPEN and CLOSED indicating lights.
   e. Ac motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.
   f. Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.
   g. Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.

5. Limit Switch:
   a. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
   b. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
   c. Housed in actuator control enclosure.
6. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.
7. Manufacturers and Products:
   a. Rotork Controls.
   b. Flowserve Limitorque.
   c. AUMA.

2.07 ACCESSORIES

A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each valve 2 inch and larger, bearing valve tag number shown on Drawings.

B. Limit Switch:

1. Factory installed NEMA 4X limit switch by actuator manufacturer.
2. SPST, rated at 5 amps, 120 volts ac.

C. T-Handled Operating Wrench:

1. **[A:]** each galvanized operating wrenches, 4 feet long.
2. Manufacturers and Products:
   a. Mueller; No. A-24610.
   b. Clow No.; F-2520.
3. **[B:]** each galvanized operating keys for cross handled valves.

D. Extension Bonnet for Valve Operator: Complete with enclosed stem, extension, support brackets, and accessories for valve and operator.

1. Manufacturers and Products:
   a. Pratt;
   b. DeZurik;

E. Floor Stand:

1. Nonrising, heavy pattern, indicating type.
2. Complete with solid extension stem, coupling, handwheel, stem guide brackets, and yoke attachment. Stem length as required to connect valve operating nut and floor stand.

3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 304 stainless steel.
5. Manufacturers and Products:
   a. Clow; Figure F-5515.
   b. Mueller, Figure A-26426.

F. Floor Box:

1. Plain type, for support of nonrising type stem.
2. Complete with solid extension stem, operating nut, and stem guide brackets. Stem length as required to extend valve operating nut to within 3 inches of finish floor.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 304 stainless steel.
5. Manufacturers and Products:
   a. Neenah Foundry; R 7506.
   b. Clow; No. F5690.

G. Chain Wheel and Guide:

1. Handwheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
   a. Clow Corp.; Figure F-5680.
   b. Walworth Co.; Figure 804.
   c. DeZurik Corp.; Series W or LWG.

H. Cast-Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 5-1/4-inch ID shaft.

1. Box: Cast iron with minimum depth of 9 inches.
2. Lid: Cast iron, minimum depth 3 inches, locking type, marked SEWER.
3. Extensions: Cast iron, ABS, or PVC pipe.
4. Two-piece box and lid for valves 4 inches through 12 inches, three-piece box and lid for valves larger than 12 inches with base sized for valve.
5. Valve extension stem for valves with operating nuts 3 feet or greater below finish grade.
6. Manufacturers and Products:
   a. East Jordan Iron Works; Cast-Iron Valve Boxes.
   b. Bingham & Taylor; Cast-Iron Valve Boxes.

I. Concrete Valve Box: Designed for traffic loads, sliding type, with minimum of 10-inch ID shaft.

1. Box: High-density, reinforced concrete, minimum depth 12 inches, cast-iron ring seat.
2. Lid: Cast iron, minimum depth 3 inches, marked SEWER.
3. Extensions: ABS, PVC, or cast-iron pipe.
4. Manufacturers and Products:
   a. Christy Concrete Products; G Series.
   b. BES Concrete Products; G Series.

J. Indicator Post Assembly:

1. Cast or ductile iron post head, bell, and wrench with cast or ductile iron or steel barrel.
2. Plexiglas or equal protected window to indicate OPEN and CLOSED position.
3. Padlockable eye bolt for wrench.
4. Adjustable bury depth. Bury depth as required for valve installation.
5. UL Listed and FM Approved.
6. Manufacturers and Products:
   a. Clow; Style 2945.
   b. Mueller; A-20806.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
   a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
   b. Install valves in location for easy access for routine operation and maintenance.
   c. Install valves per manufacturer's recommendations.
2. Gate, Globe, and Ball Valves:
   a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
   b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Eccentric Plug Valves:
   a. Unless otherwise restricted or shown on Drawings, install valve as follows:
      1) Liquids with suspended solids service with horizontal flow: Install valve with stem in horizontal position with plug up when valve is open. Install valve with seat end upstream (flow to produce unseating pressure).
      2) Liquids with suspended solids service with vertical flow: Install valve with seat in highest portion of valve (seat up).
      3) Clean Liquids and Gas Service: Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).
4. Butterfly Valves:
   a. Unless otherwise restricted or shown on Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
   b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
   c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
   d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.
   e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.

5. Check Valves:
   a. Install valve in accordance with manufacturer's instructions and provide required distance from immediate upstream fitting.
   b. Install valve in vertical flow (up) piping only for gas services.
   c. Install swing check valve with shaft in horizontal position.
   d. Install double disc swing check valve to be perpendicular to flow pattern when discs are open.
6. Solenoid Valves: Install in accordance with manufacturer's instructions.

E. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

H. Torque Tube: Where operator for quarter-turn valve is located on floor stand, furnish extension stem torque tube of a type properly sized for maximum torque capacity of valve.

I. Floor Box and Stem: Steel extension stem length shall locate operating nut in floor box.

J. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet of finish floor. Where chains hang in normally traveled areas, use appropriate "L" type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station.

3.02 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer's data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER'S SERVICES

A. Valve(s) as listed below require manufacturer's field services:

1. V504 V754, V500**.**

B. Manufacturer's Representative: Present at Site for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for inspection.
2. 1/2 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

C. See Section 01 43 33, Manufacturers' Field Services, Section 01 91 14, Equipment Testing and Facility Startup.

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification.

1. Electric Actuated Valve Schedule.
2. Pneumatic Actuated Valve Schedule.
3. Self-Regulated Valve Schedule.

END OF SECTION

Electric Actuated Valve Schedule

Tag Number	Valve Type	Actuator Power Supply	Valve Size (inches)	Process Fluid	Maximum Operating Flow (gpm)	Maximum ΔP (psi)	Service	Travel Time (Seconds)	Control Feature Modifications/ Supplements
		[A: -volt], **[B: single]** **[C: three]**-phase							
		[A: -volt], **[B: single]** **[C: three]**-phase							

Service: O/C = Open-Close, T = Throttling, M = Modulating

Control Feature Modifications/Supplements:

A = Actuator shall open valve upon loss of signal.

B = Actuator shall close valve upon loss of signal.

C = Actuator shall remain in last position upon loss of signal.

D = Local OPEN-CLOSE momentary pushbuttons that must be continuously depressed to initiate/maintain valve travel; travel stops when pushbutton is released or when end of travel limit is reached.

E = Remote OPEN-CLOSE maintained dry contacts; travel stops when remote contact opens, or when end of travel limit is reached.

F = Three 24-volt dc interposing relays for remote OPEN-STOP-CLOSE control. Relays powered externally, thereby permitting valve control from greater distances.

G = Motor and control enclosure(s) NEMA 250, Type 4 with 120-volt space heaters.

H = Motor and control enclosure(s) NEMA 250, Type 6 (IP 68) with 120-volt space heaters.

I = Motor and control enclosure(s) NEMA 250, Type 7 with 120-volt space heaters.

J = Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.

K = 120-volt secondary control power transformer.

L = Externally operable power disconnect switch.

[A: M = _____.]

Pneumatic Actuated Valve Schedule								
Tag Number	**Valve Type**	**Size (inches)**	**Fluid**	**Maximum Operating Flow**	**Maximum ΔP (psi)**	**Service**	**Travel Time (Seconds)**	**Actuator Type and Control Features**

Service: O/C = Open-Close, T = Throttling, M = Modulating

Actuator Type and Control Features:

A = Vane Type Actuator.

B = Cylinder Type Actuator.

C = Diaphragm Type Actuator.

D = Valve shall open upon loss of signal.

E = Valve shall remain in last position upon loss of signal.

FC = Fail Close on loss of air supply (Air to open, spring to close).

FO = Fail Open on loss of air supply (Air to close, spring to open).

G = Positioner with 3 to 15 psig pneumatic input signal.

H = Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.

I = Visual indicator.

J = Manual handwheel override.

L = Limit switch.

Self-Regulated Valve Schedule							
Tag No.	**Valve Type No.**	**Size (inches)**	**Inlet* Pressure**	**Outlet* Pressure**	**Maximum psig**	**Flow (gpm)**	**Fluid**
*Inlet Pressure = Set pressure for pressure relief valve or downstream set pressure for pressure reducing valve.							

SECTION 15730
AIR-CONDITIONING EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 390, Performance Rating of Single Package Vertical Units (SPVU).
2. Air Moving and Conditioning Association (AMCA): Bulletin 300, Setup No. 1.
3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   b. 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings.
4. American Society of Mechanical Engineers (ASME): BPVC Section IX, Welding and Brazing Qualifications.
5. International Organization for Standardization (ISO): 9001, Quality Management Systems - Requirements.
6. National Electrical Manufacturers Association (NEMA).
7. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
8. National Fire Protection Association (NFPA): 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
9. Underwriters Laboratories Inc. (UL): 94, Safety Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
10. International Energy Conservation Code (IECC) – 2009 with city of Houston Amendments.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for all products specified.

b. Manufacturer's standard finish color selection for enclosure finishes.
c. Complete performance data that will indicate full compliance with Specification: Include heating and cooling performance data at design operating conditions.

B. Informational Submittals:

1. Manufacturer's documentation that media filter modules rated UL Class 1.
2. Manufacturer's Certificate of Compliance.
3. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
4. Sample copy of guarantee.
5. Test reports.
6. Operation and Maintenance Data.
   a. Include wiring and control diagrams for equipment.
   b. Include as-built version of equipment schedules.

1.03 QUALITY ASSURANCE

A. Heating and Cooling Equipment: Minimum operating efficiencies, defined as COP and EER, as specified in ASHRAE 90.1-2007, or IECC-2009 with City of Houston Amendments, whichever is more stringent.

B. Unit shall be rated per AHRI 390.

C. Units shall be certified by UL and CSA, and shall be UL or ETL listed and labeled.

D. Cooling performance rated in accordance with AHRI testing procedures.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

B. Protection of Equipment:

1. Box, crate, or otherwise protect from damage and moisture during shipment, handling, and storage.

2. Protect from exposure to corrosive fumes and keep thoroughly dry at all times.
3. Store motors, drives, electrical equipment, and other equipment with antifriction or sleeve bearings in weathertight and heated storage facilities prior to installation.
4. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

1.05 WARRANTY:

A. Equipment shall be free from defects in materials and workmanship for a period of 5 years for compressor, and for a period of 5 years for all parts. Warranty period shall start from date of installation as stated on warranty card; or from date of shipment if no warranty card is returned to Manufacturer.

1.06 EXTRA MATERIALS

A. Furnish and provide to Owner the following materials:

Item	Quantity
Fan Belts	One complete set for each belt-driven fan.
Filters	One complete set per unit.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish and install a self-contained, vertical, exterior wall mount, through-the-wall air conditioner. The unit shall be approved and listed by Intertek ETL Listed (ETL US/C). Unit shall be factory assembled, pre-charged, pre-wired, tested and ready to operate. Unit performance shall be certified in accordance with the Air Conditioning Heating and Refrigeration Institute (AHRI) Standard 390-2003 or Single Package Vertical Units. Unit efficiency shall be specified by EER. Manufacturers: Capacities shall be as indicated on Drawings.

2.02 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.03 CONSTRUCTION FEATURES

A. Cabinet:

1. Construction shall be a single, enclosed, weatherproof casing constructed of 20-gauge galvanized steel, stainless steel, or aluminum. Unit base is constructed of 16-gauge galvanized steel for painted and aluminum cabinets, stainless steel for stainless cabinets. Each exterior casing panel to be bonderized and finished with baked-on exterior polyester enamel paint prior to assembly. The baked-on cured paint finish shall pass the industry rub test with a minimum of 72 rubs MEK (Methyl Ethyl Ketone) or standard rub test of a minimum of 100 rubs using Tolulene. Cooling section shall be fully insulated with 1-inch fiberglass to prevent sweating and to muffle sounds. Openings shall be provided for power connections. Access openings appropriate for outside structure to all fan motors and compressor for making repairs and for removing internal components without removing unit from its permanent installation. Fresh air intake and outdoor coil shall be protected from intrusions by a sturdy metal grating with less than 1/4 inch openings.
2. Color: Beige.
3. Supply Grille: Adjustable aluminum double deflection type, factory installed.
4. Return Grille: Aluminum, fixed blade type, factory installed.

B. Drain Pan: Drain pan shall be constructed of 20-gauge galvanized steel, bonderized and finished with baked-on exterior polyester enamel paint.

C. Insulation: Insulation shall be foil faced for ease of cleaning.

D. Mounting Brackets:

1. Full-length side mounting brackets shall be an integral part of the cabinet. Bottom mounting bracket shall be provided.
2. Cabinet: Bottom mounting bracket shall be provided.

E. Refrigeration System:

1. Unit(s) shall use a high efficiency scroll compressor. The compressor shall be covered by a 5-year parts warranty. The refrigeration circuit shall be equipped with factory installed high and low pressure controls and liquid line filter dryer. The refrigeration control shall be a factory installed capillary tube. Compressor shall be mounted on rubber grommets. Unit shall be provided with R-410A (HFC) non-ozone depleting refrigerant.

F. Condenser Fan Motor: The condenser fan, motor and shroud shall be of slide out configuration for easy access.

G. Indoor Blower Motor: The indoor blower motor shall be twin wheels with forward curve blades. Motor shall be high efficiency PSC type.

H. Electrical Components: Electrical components are easily accessible for routine inspection and maintenance through front service panels. Circuit breaker disconnect access is through lockable access panel.

I. CONTROL CIRCUIT:

1. The internal control circuit shall consist of a current limiting 24V ac type transformer. To prevent rapid compressor short cycling, a five minute time delay circuit shall be factory installed. A low-pressure bypass shall be factory installed to prevent nuisance tripping during low temperature start-up.

J. Heat Options: The air conditioner shall have a factory installed electric resistance heater. Heater shall include automatic limit safety controls.

K. Ventilation Options: A blank off plate covers the air inlet openings that restrict any outside air from entering the unit. The blank off plate should be utilized in applications where outside air is not required to be mixed with the conditioned air.

L. Filter Options: 2-inch Fiberglass – Pleated – MERV 6.

M. Unit Control Options:

1. Low ambient control.
2. High Pressure control.

N. Operating Controls (Field Installed): Electronic programmable, auto changeover with field controller. Refer to drawings and sequence of operations.

O. Manufacturers: Other approved equal.

2.04 FIELD EQUIPMENT CONTROLLER

A. Input power: 18 to 32V ac, 60/50Hz, power is supplied from A/C #1 and/or A/C #2.

B. Isolation circuitry: no line or low voltage phasing required.

C. Backup power: connection for -24V dc or -48V dc (-20 to -56V) maintains microprocessor operation, front panel indication, and alarm relay operation during commercial power outages.

D. Digital display: 4-character LCD.

E. Temperature display: F or C.

F. HVAC outputs: Form A (NO) relays (1A @ 24V ac).

G. Cooling control stages: 2 for each A/C unit (4 total).

H. Heating control stages: 1 for each A/C unit, 2 for each heat pump if so configured.

I. Dehumidification circuit: requires optional humidity controller that closes on-rise as input signal, Bard Part #8403-038 recommended. Both HVAC units must be equipped with electric heat for this sequence to work properly.

J. Locking feature, allows controller to be “locked” so no unauthorized changes to programming can be made.

K. Operating temperature range: 0 to 120F (-18 to 49C) • Storage temperature range: -20 to 140F.

L. Temperature accuracy: Plus or minus 1 degrees F from 60-85 degrees F; plus or minus 1 percent outside 60-85 degrees F.

M. Lead/lag changeover time: 0 to 30 days.

N. Timing accuracy: Plus or minus 1 percent.

O. Inter-stage time delay: 10 seconds between stages.

P. Inter-stage differential: Adjustable

Q. On-Off differential: Adjustable.

R. Cooling set point range: 65 to 90 degrees F.

S. Comfort setting-Cooling 72 degrees F, Heating 68 degrees F, for 1 hour.

T. Dead band (difference between cooling and heating set points): 2 degrees F to 40 degrees F (1C to 24C).

U. Fire/smoke interface: standard NC circuit jumper, remove for connection to building system control, shuts down both A/C units immediately. Field supplied fire/smoke device must have normally closed (NC) dry contact rated at 2A 24VAC minimum. Shielded cable (22-gauge minimum) must be used and shield grounded to controller enclosure.

V. Generator run feature, inhibits lag A/C unit from operating if generator is operating (to limit amperage).

W. Memory: EEPROM for set point and changeable parameters (maintains settings on power loss).

X. Space temperature sensors: 1 local is standard, will accept up to 2 optional 35-foot remote sensors. When multiple sensors are used temperatures are averaged.

Y. LEDs for basic controller: Lead unit, Cooling stages 1 through 4, Heating stages 1 through 4, Dehumidification operation.

Z. Six (6) Push-button controls: On/Off switch-Change lead unit-Increase and Decrease set points-Program/Save-Comfort.

AA. Controller Enclosure: 20-gauge pre-painted steel, 9.25 inches Wide by 13.50 inches High by 3.00 inches Deep, hinged cover, thirteen (13) .875-inch diameter electrical knockouts.

BB. Alarms:

1. Add alarm board inputs and outputs as necessary to meet sequence of operations.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install equipment in accordance with manufacturer's recommendations, and these Specifications.
2. Set and install equipment so equipment is level and properly supported.
3. Install safety devices as recommended by manufacturer and required by code.

END OF SECTION

SECTION 15860
EXHAUST FANS

PART 1 GENERAL

1.01 DESCRIPTION

A. Description of Work: This section specifies exhaust fans and includes furnishing, installing, connecting, and starting fans. Equipment number, capacity, and location of each fan is shown on Drawings.

1.02 QUALITY ASSURANCE

A. Applicable Standards: Construction and installation of the fans shall conform to the latest revisions of the following Standards:

AMCA 210-67	Test Code for Air Moving Devices
ASME PTC 11-46	Test Code for Fans
AMCA 99	Standards Handbook
AMCA 300	Standard Test Code for Sound Rating
UL 507-1961	Underwriter's Laboratories Standard for Safety for Electric Fans
AMCA A5401	Fans, Standard Classification for Spark Resistant Construction

B. Tests:

1. Conduct factory tests to determine capacity, efficiency and brake horsepower at design conditions, and at other conditions to establish performance curves.
2. Conduct field tests to determine fan speed, horsepower, static pressure and cfm.

C. Requirements for Regulatory Agencies: Conform to requirements of Section 15010, Basic Mechanical Requirements.

1.03 SUBMITTALS

A. Shop Drawings: Submit shop drawings in accordance with Division 1, General Requirements.

PART PRODUCTS

2.01 EQUIPMENT

A. Exhaust fans are scheduled on Drawings.

B. The exhaust fans shall be as manufactured by the following: Greenheck, or approved equal.

2.02 IDENTIFICATION

A. Equipment Number: Show equipment number on nameplate attached to fan, control panel, and motor starter.

B. Nameplates:

1. Provide laminated phenolic nameplates for each fan. Nameplates shall have black exterior and white core, neatly beveled edges, and shall show white letters on a black background.
2. Inscribe on the nameplate the equipment number and function of the fan.
3. Attach nameplates to fans.

C. Stencils: Stencil equipment number and fan function on fan so that equipment number can be read from floor. Stenciled letters and figures shall be no smaller than 1/2 inch high and shall be white on black background.

D. Seals: All fans must bear the AMCA certified rating seal.

2.03 VANE AXIAL HIGH PRESSURE FANS

A. General:

1. Base fan performance at standard conditions (density 0.075 Lb. /ft3).
2. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
3. Each fan shall be belt drive in AMCA arrangement 9 only with hub positively secured with a steel taper lock bushing keyed to the fan shaft.
4. Fans are to be equipped with lifting lugs.
5. After fabrication all carbon steel components shall be cleaned and chemically treated by a phosphatizing process to insure proper removal of grease, oil, scale, etc. Fan shall then be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL 7023, concrete grey. Coating must exceed 1,000-hour salt spray under ASTM B117 test method.

B. Fan Housing and Outlet:

1. Fan housing shall be fabricated from heavy gauge steel with prepunched flanges at both ends.
2. A minimum of seven heavy gauge, straightening vanes shall be welded to the fan housing downstream from the rotor.
3. Fan housing shall be constructed of rolled steel with a continuous seam weld. Housing to be coated with a minimum of 3 mils of Permatector, an electrostatically applied and baked polyester urethane. Finish color shall be RAL 7023, concrete grey. Coating must exceed 1,000 hour salt spray under ASTM B117 test method.
4. Motor support framework to be constructed of structural steel that is suitable to handle the weights of the motor and propeller. Motor supports within the fan housing to be welded to the fan casing. Bolted construction is not acceptable. All support framework to be coated with a minimum of 3 mils of Permatector, an electrostatically applied and baked polyester urethane. Finish color shall be RAL 7023, concrete grey. Coating must exceed 1,000 hour salt spray under ASTM B117 test method.
5. OSHA compliant belt guard or motor cover to be included to completely cover the motor pulley and belt(s).

C. Fan Impeller:

1. Rotor blades and hub shall be heat-treated cast aluminum alloy A356-T6 with blade bases and hub sockets precision machined. Blades shall be attached to the hub with steel studs and self-locking nuts.
2. Rotor blade pitch shall be manually adjustable (within horsepower limitations) without removing the propeller from the fan shaft.
3. A taper lock bushing shall be used to mount the propeller to the motor shaft.
4. The propeller diameter and casing inside diameter shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

D. Fan Motors and Drives:

1. Motors shall meet or exceed EPACT (Energy Policy ACT) efficiencies. Motors to be premium efficiency type NEMA T-frame, 1800 or 3600 RPM, Totally Enclosed Fan Cooled (TEFC), with a 1.15 service factor.
2. Drive belts and sheaves shall be sized for 150% of the fan operating brake horsepower, and shall be readily and easily accessible for service, if required.

3. Fan shaft to be turned and polished steel that is sized so the first critical speed is at least 25 percent over the maximum operating speed for each pressure class.
4. Fan shaft bearings shall be Air Handling Quality, bearings shall be heavy-duty grease lubricated, self-aligning or roller pillow block type.
5. Air Handling Quality bearings to be designed with low swivel torque to allow the outer race of the bearing to pivot or swivel within the cast pillow block. Bearings shall be 100% tested for noise and vibration by the manufacturer. Bearings shall be 100% tested to insure the inner race diameter is within tolerance to prevent vibration.
6. Bearings shall be selected for a basic rating fatigue life (L-10) of 40,000 hours at maximum operating speed for each pressure class {Average Life or (L-50) of 200,000 hours}.
7. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed.
8. Bearings shall have extended copper lube lines with Zerk fittings to allow for lubrication.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to Drawings, manufacturer's instructions and approved Shop Drawings.

END OF SECTION

SECTION 15900
THEMOSET FIBERGLASS REINFORCED PLASTIC (FRP) DUCTS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes requirements necessary to furnish and install complete fiberglass-reinforced plastic (FRP) ductwork systems with pressure classifications ranging from negative 30 inches water column (wc) to positive 30 inches wc.

B. Ductwork systems specified under this Section include: Headworks Facility Exhaust.

C. In the event of conflict regarding FRP ductwork requirements between this Section and another Section, the provisions of this Section govern.

1.02 REFERENCES

A. Abbreviations and Acronyms:

1. American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. (ASHRAE).
2. American Society for Testing and Materials (ASTM).
3. Backdraft damper (BDD).
4. Factory Mutual (FM).
5. Fiberglass-reinforced plastic (FRP).
6. Heating, Ventilating, and Air Conditioning (HVAC).
7. International Building Code (IBC).
8. International Mechanical Code (IMC).
9. National Fire Protection Association (NFPA).
10. Polyvinyl chloride (PVC).
11. Radius / diameter (r/d).
12. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
13. Water column (wc).
14. Water gauge (wg).

B. Definitions:

1. Duct: A tube or channel, including fittings through which a gas moves.
2. Ductwork: A system of interconnected ducts and duct accessories, including, but not limited to, isolation and balancing dampers, access doors, turning vanes, flexible connections, hangers and supports, and other miscellaneous items required for a completely operable and adjustable system.

C. Reference Standards:

1. American Society for Testing and Materials (ASTM) D2996, Standard Specification for Filament-wound "Fiberglass" (Glass-fiber-reinforced Thermosetting-resin) Pipe.

2. ASTM C581, Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-fiber-reinforced Structures Intended for Liquid Service.
3. ASTM D4097, Standard Specification for Contact-molded Glass-fiber-reinforced Thermoset Resin Corrosion-resistant Tanks.
4. National Fire Protection Association (NFPA) 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
5. NFPA 91, Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying.
6. NFPA 318, Standard for the Protection of Cleanrooms.
7. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Publications Accepted Industry Practice for Industrial Duct Construction.
8. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Publication Thermoset FRP Duct Construction Manual.
9. SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems.

1.03 SUBMITTALS

A. Drawings of the duct layout at the same scale as the building drawings or a minimum of 1/8-inch scale, showing location and dimensions of main and branch runs, fittings, offsets, takeoffs, and accessories.

1.04 QUALITY ASSURANCE

A. The SMACNA publication Thermoset FRP Duct Construction Manual generally governs the material thicknesses, and the fabrication and installation techniques for systems specified in this Section of Work. SMACNA criteria are superseded by the requirements of this Section.

B. Fabricate and install FRP ductwork utilizing qualified, experienced mechanics that have a minimum of 5 years' experience with lay-up, filament wound or contact molded duct, and fabrication and joining of this type of material.

C. Provide resins approved for the intended use in the fabrication of FRP ductwork. Apply resin in accordance with the Supplier's published technical criteria.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and firestopping materials to site in original unopened containers or bundles, with labels indicating:

1. Manufacturer.
2. Product name and designation.
3. Color.
4. Expiration period for use.
5. Pot life.
6. Curing time.
7. Mixing instructions for multi-component materials.

B. Store and handle sealant and firestopping materials in accordance with manufacturer's written recommendations.

C. Ductwork:

1. Protect ductwork and fittings from damage during shipping, storage, and handling using wood or cardboard flange covers over shrink-wrapped duct seal, applied to ends of ductwork to prevent end damage, and prevent dirt and moisture from entering ducts and fittings. Separately package each piece without internal nesting of duct pieces.
2. Inspect shipments upon delivery. Note damages and discrepancies on bill of lading and notify manufacturer within 24 hours.
3. Store ductwork on cardboard, Styrofoam, or similar material, out of traffic areas. Where possible, store ductwork indoors and protect from dirt and debris. Where necessary to store outdoors, store above grade and enclose with waterproof wrapping to protect from dirt and debris.
4. If surface is scratched, contact manufacturer for repair instructions. Repair or replace ductwork as determined by the manufacturer.

1.06 COORDINATION

A. The Drawings do not attempt to show exact details of FRP ductwork. No extra payment will be allowed for obstruction by work of other Trades or local obstructions to the work which require offsets. Where diagrams have been made to show duct connections, do not use the diagrams for obtaining material quantities.

B. Submit changes in location of equipment or ductwork, advisable in the opinion of Contractor, for review before proceeding with the Work. Verify measurements and dimensions at the site.

C. Duct sizes shown on the Drawings represent the nominal free area required for that service. Where changes in duct dimensions are necessary to coordinate the installation, Contractor may change to an equivalent duct area with different dimensions as determined using a Trane Ductulator, or Carrier or American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. (ASHRAE) equivalence charts.

D. Coordination with Existing Conditions and Other Trades:

1. Coordinate the installation of ductwork with existing conditions and the work of other Trades to allow the installation of work and the proper operation of dampers, operators, duct access doors, and operation and removal of blast gate dampers. Correct deficiencies in operation at no additional cost to Owner.
2. Where existing threaded rod, strut material, miscellaneous supports, or conduit or piping under 1 inch diameter obstructs the passage of the ductwork, relocate the obstruction at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Resins:

1. CoREZYN VE 8440 (Interplastics).
2. Dion VER 9300 FR (Reichhold).
3. Hetron 992 (Ashland Chemical).
4. Derakane 510 (Dow).

2.02 FRP DUCTWORK - MATERIALS

A. Internal Surface and Layer:

1. Construct the internal liner of materials resistant to the chemicals listed above.
2. Provide a corrosion-resistant surface and layer at least 100 mil thick, specifically layed up as a corrosion barrier, and formed separately from the materials and procedures of the structural layers. Provide thickness necessary for a 25-year duct life, as determined by the duct manufacturer.
3. Use an open Nexus synthetic veil, style 100-010 or style 111-010, provided by Precision Fabrics Group, for an internal liner with a minimum 10 mil thickness.
4. Provide three layers of 1.5-ounce-per-square-foot chopped strand matt and spray-up chopped borosilicate glass to make up the balance of the internal liner to achieve a minimum 100 mil total thickness using proper ratios of resin to glass. Allow layers to gel completely prior to continuing with the structural layer.
5. Resins used for this internal layer:
   a. Derakane 510A.
   b. Hetron FR992.
   c. CoREZYN VE 8440.
   d. Dion FR3900.
6. Provide resins that carry a flame spread rating of 20 or less, and smoke contribution rating of unrated (in excess of 1,000).

B. Structural Layer:

1. Fabricate the structural layer of duct by either filament-wound or hand-lay-up techniques to achieve the total dimensional thickness necessary to achieve the pressure rating listed in Attachment A: Fiberglass Reinforced Plastic (FRP) Ductwork Schedule attached to this Section.
2. Provide a smooth outer surface with no exposed glass fiber ends.
3. If necessary for structural integrity on thin ducts, fabricate the internal corrosion layer and the structural layer from resistant resins such as specified in FRP Ductwork, above.
4. Owner-review and -approval of the final resin selection is required.

C. External Layer:

1. Indoor Ductwork:
   a. Provide fire protection from an external source for the exposed external surface of FRP ductwork installed inside the building shell.
   b. Provide duct with a flame spread rating of 25 or less, and a smoke contribution of 50 or less.
   c. Provide indoor ductwork with a finished appearance in the white color spectrum, to be readily distinguishable from ductwork used outdoors.
   d. Provide a single layer of 8 mil minimum dry film thickness (DFT) intumescent paint coating manufactured by Albi or Sherwin-Williams, to act as a cellular foaming agent to protect the duct.

D. Gaskets:

1. Polytetrafluoroethylene (PTFE): Fully expanded, 100 percent PTFE form-in-place gasket material, 3/8-inch thickness, W.L. Gore and Associates, Inc.
2. Ethylene Propylene Diene Monomer (EPDM): EPDM sheet, minimum 1/8-inch thickness, use durometer of 40 shore only for 2-inch, 6-inch, 10-inch, and 20-inch diameter flanged connections, or where manways have less than 3-1/2-inch center-center bolt spacing.

E. Branch Taps:

1. Provide factory-applied taps.
2. For taps 6-inch diameter and larger, provide the inside surfaces of the tap joints with two layers of glass mat and veil thoroughly impregnated with resin, in addition to that required on the exterior of the connection for structural strength.
3. Provide branch taps at a 45 degree entry to the mains at horizontal centerlines and on main ducts after transitions located upstream, or at 90 degree entry with gored tee where shown on the Drawings.

F. Transitions: Provide one-piece transitions and tapers whose length is 2-1/2 times the difference of the diameters of the ducts being connected.

G. Radius Elbows: Provide round elbows up to 36-inch diameter as a single-piece, smooth flow type. Provide elbows above 36 inches as five-piece gored elbows. Provide long radius elbows with a minimum of radius / diameter (r/d) equal to 1.

H. Design Criteria – Duct Systems

1. Provide FRP ductwork in accordance with the current editions of ASHRAE Handbook, SMACNA Thermoset FRP Duct Construction Manual, NFPA 91 Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids and the International Mechanical Code (IMC). Where conflict among these references arises, follow the most stringent source.

2. Ductwork fabricated for this Project must meet the requirements of:
   a. ASTM D2996 for filament wound pipe.
   b. ASTM C581 for chemical resistance of thermosetting resins.
   c. ASTM D4097 for hand layed-up shapes.
   d. The IMC for general non-metallic ductwork.
3. Service Duty:
   a. Fabricate ductwork equaling or exceeding minimum wall thickness and reinforcing as scheduled in the SMACNA Thermoset FRP Duct Construction Manual to comply with duct pressure and system classifications as scheduled in Attachment A: Fiberglass Reinforced Plastic (FRP) Ductwork Schedule, unless otherwise noted on the Drawings.
   b. Operating Temperature:
      1) Indoor Ductwork:
         a) Normal Conditions: 110 degrees F.
   c. Maximum Unsupported Stack Height: 15 feet for sizes 36-inch diameter and larger, based on a maximum anticipated wind loading of 25 pounds per square foot against the projected area.

2.03 INDUSTRIAL FLEXIBLE DUCTWORK

A. Chemically Resistant (CR) Exhaust (Type CR):

1. Acceptable Manufacturer: Gen-Line Series 900 (blue) by Darcy Rubber Corporation.
2. Description: Wire-wound air duct fabricated with smooth, reinforced polyvinyl chloride (PVC) air passageway, rated for 5-inch Hg vacuum. Provide SS band clamp at equipment connection. Exposed wire is prohibited.

2.04 HANGERS AND SUPPORTS

A. Design Criteria for Supports, Anchorage, and Restraints for FRP Duct Systems:

1. General:
   a. Design supports, anchorages, and seismic restraints for equipment, piping, and ductwork that are not shown on the Drawings.

   b. Provide supplementary steel as required to eliminate twisting, torsion, or lateral bending in the framing members. Provide isolation of ductwork to structural support members at support points.
2. Engineered Support Systems: Provide the design, details, and seal of a Professional Engineer registered in the state of Texas, in which the Project is located, for the following support systems:
   a. Support frames that provide support for ductwork and equipment from above.
   b. Equipment and support frame anchorage to supporting slab or structure.

B. General:

1. Provide duct hanger and support material gauges to comply with details on the Drawings. Where details are not provided, support FRP ductwork using details and methods described in the SMACNA Thermoset FRP Duct Construction Manual.
2. Externally bond anchors to the duct when required. Driving screws into or other penetrations of the duct are not permitted.
3. Provide supports which are independent of equipment and walls.

C. Upper Attachments:

1. Concrete Construction:
   a. Cast-in-place inserts as specified in another division of work are acceptable if approved by Owner.
   b. Expanding concrete anchors as specified in another division of work may be used if approved by Owner.
   c. The use of powder-actuated fasteners is prohibited without prior written consent by Owner.
2. Steel Construction:
   a. Acceptable Manufacturers:
      1) Fee and Mason Manufacturing Company.
      2) Anvil (Grinnell).
      3) Cooper B Line.
   b. Support ductwork from structure or supplementary steel, utilizing beam clamps designed for the intended service. Other support hardware is prohibited without prior written consent by Owner. Support from metal decks above is prohibited. Provide supplementary steel as detailed and as required.

D. Support Frames: Structural steel shapes or strut frames for support of ductwork, accessories, and Heating, Ventilating, and Air Conditioning (HVAC) system components with nuts, bolts, fittings, etc. compatible with the frame material.

2.05 FLEXIBLE FAN CONNECTORS

A. Acceptable Manufacturers:

1. Proco Products Inc., Series 500.
2. Ventfabrics, Ventel.
3. Other approved vendor.

B. Description:

1. Corrosion-resistant flexible connectors designed to match inlet and outlet flanges of industrial fans and duct systems. Provide flexible fabric of Buna-N, Viton or Teflon-coated 14-ounce-per-square-yard glass fabric of a pressure rating to match the fan design capacity.
2. Provide materials and hardware designed for outdoor installation.

2.06 SOURCE QUALITY CONTROL

A. Factory Inspection:

1. Owner maintains the right to tour the FRP duct manufacturer's plant during fabrication performed on ductwork intended for this Project.
2. Notify Owner when production has been completed on the first 50 linear feet of fabricated ductwork. After that date, Owner may exercise the option, without advance notice, to tour the plant and inspect stages of fabrication to ensure that quality control is being maintained.

B. Number and log manufactured duct sections. Include piece number, description, and date of manufacture in each log entry. Deliver log information with each shipment. Maintain a field copy of logs for review by Owner.

C. Acceptance of Fabricated Ductwork:

1. Provide acceptance of factory-fabricated ductwork based on laboratory analysis of the factory-supplied and field-supplied test sample specimens and Owner's inspection of the ductwork during the fabrication procedure.
2. Do not install ductwork on the Project until Owner approves the test results to verify the fabricated product complies with the technical requirements specified herein.
3. Analyze factory and field test sample specimens to determine:
   a. Tensile and flexural strength.
   b. Barcol hardness.
   c. Glass content.
   d. Edge compression properties.
   e. Visual quality of laminate.
   f. Thickness measurements of construction layers.
   g. Acetone-sensitive surface cure test.
4. Follow this additional step if a duct sample fails to meet either the requirements of the resin Supplier's technical data or the fabrication steps of this Section:
5. Contract with the chosen laboratory for services for the same test procedures described above on 3 new sample specimens removed from ductwork stockpiled for construction on the Project site. Written rejection by Owner of a section of the ductwork constitutes noncompliance. Remove nonconforming material from the construction site and replace with new material conforming to these requirements.
6. Take new test sample specimens from ductwork fabricated as replacement to nonconforming material, and repeat the tests.
7. Install stockpiled material upon receiving written acceptance by Owner.

PART 3 EXECUTION

3.01 PREPARATION

A. Demolition or Connection to Existing Fume Exhaust System: Follow Owner's Health and Safety guidelines and industry regulatory practices in the removal or modification of existing ductwork. Consider existing ductwork as hazardous and contaminated, and treat accordingly.

3.02 INSTALLATION

A. General:

1. Duct Sizes: Sizes shown on the Drawings are inside duct dimensions and represent the net-free dimensions of the duct.
2. Changes of Direction: Install the entire duct system with a minimum number of bends and transitions.
3. Accessibility: Position ductwork to allow easy access for maintenance and repair of adjacent equipment to new and existing components, and to allow adequate space for tube removal or other repairs.
4. Install ducts so they do not obstruct passageways, or interfere with equipment access or operation.
5. Install material and equipment as shown on the Drawings and described herein and as required by the applicable codes of the Project site. Where diagrams have been made to show duct connections, do not use these diagrams for obtaining material quantities.
6. Adjust equipment and leave in a condition satisfactory to Owner.
7. Utilizing the affected Trades, prepare the structural components of the building as required for equipment and ductwork.
8. Remove and reinstall work which is deemed unsatisfactory until the written acceptance of Owner is obtained. Provide not more than 1-inch separation space for flexible connections which are not self-supporting under the system operating pressure and conditions.

B. Purchased Components: Install purchased ductwork components in accordance with the manufacturer's written instructions. Seal connections as specified above.

C. Connections to Equipment:

1. Install continuous welded flanges to match connection points on equipment and accessories.
2. Make transitions in ductwork from rectangular to round to accommodate the sizes of factory-fabricated equipment, e.g., coils and dampers. The use of safing in lieu of transitions is not allowed.

3.03 INSTALLATION OF INDUSTRIAL FLEXIBLE DUCTWORK

A. Installation:

1. Make connections at ends using a SS draw-band strap. Install the strap to be retained by providing a welded bead on the duct collar to retain the draw band strap.
2. Reducing the free area of the duct by crimping is prohibited. Avoid bends in excess of 90 degrees.
3. Trim excess flex duct to the minimum required length.
4. Install and support duct to prevent condensation from collecting in the flexible ductwork.

3.04 DUCT HANGERS AND SUPPORTS

A. General Support Locations:

1. Locate hangers of ducts penetrating walls or partitions as though the walls will contribute no support to the duct.
2. Install hangers in pairs on exact opposite sides of duct. Install duct supports from floors and walls when necessary.
3. Install hangers at the midpoint of small-sized and medium-sized (less than 10 square feet) square elbows. On wide square elbows, install additional hangers at maximum allowable intervals (or less) measured along the heel lines of the elbows.
4. Provide one set of hangers at the midpoint of small-sized and medium-sized horizontal radius elbows with greater than 20 degree offset. Install one or more supplementary hangers along the inside and outside arcs of large-radius elbows of an angle when the length of these arcs exceeds the maximum hanger spacing length for that duct size.
5. Provide at least one set of hangers for short duct branches 3 feet or less in length.
6. Provide each duct riser with a minimum of two supports completely spanning the shaft opening at each floor. One pair of supports may be used to support more than one duct riser, provided that the strength of the supports is increased appropriately and proper additional supplementary steel is used at the extra risers.
7. Support duct risers located between floors that are more than 15 feet high at each floor and halfway points between floors. The distance between intermediate supports on high floors should not exceed 12 feet for round ducts, or 10 feet for rectangular ducts (intermediate hangers may be supported from an adjacent wall or hung by rods from supports on the floor above).

B. Specific Support Locations – Locate Duct Hangers:

1. Approximately 2 inches to 24 inches from flexible connections at fans.
2. Approximately 12 inches to 36 inches from the main duct to the first hanger of long branch ducts.

3. Approximately 2 inches to half the duct width, plus 2 inches from the vertical centerline of the lower elbow of short vertical offsets made with vaned square elbows. The width refers to the dimension of the elbow in the plane of the turn. The heavier the duct, the closer the hanger should be to the centerline of the elbow.
4. Approximately 2 inches to half the duct width, plus 2 inches from the vertical centerline of the bottom and top elbows of vaned square elbow offsets over 8 feet high. Diameters of hanger rods of heavy offsets must be increased proportionately. The heavier the duct, the closer the hanger should be to the centerline of the elbow.
5. Approximately one-eighth of the arc in from the ends of bottom and top radius elbows of vertical offsets longer than 8 feet. Short vertical offsets require hangers at the bottom elbow. Sloping offsets need at least one set of hangers at their lower-radius elbow. Fasten hangers on sloping or arched surfaces to ducts to prevent slippage.
6. Approximately 6 inches to 12 inches from transverse joints of ducts whose lengths are the same as specified hanger intervals.
7. Approximately 6 inches to 12 inches from one side of walls or partitions penetrated by ducts.

C. Support Method:

1. Support low ductwork from floors or other steel structures acceptable to Owner using struts, or structural steel shapes or bars.
2. Support ductwork suspended from overhead structure using trapeze supports for rectangular ducts, or straps for round ducts with the hanger strap wound completely around the duct. Use threaded rod for support from above.
3. Use of sheet metal screws for attaching support straps to ducts is prohibited.
4. Trim support material to minimum length after elevation is adjusted.
5. Supporting methods from pre-cast concrete elements must be submitted for review.

3.05 FIELD QUALITY CONTROL

A. Testing:

1. Prior to connection to equipment, perform a dynamic pressure test on ductwork systems using a high-pressure blower with a calibrated orifice and manometer. Provide necessary blowers, gauges, connections, and similar items required to perform the tests.
2. Repair leaks and retest until stipulated results are achieved.
3. Advise Owner 48 hours in advance of each test. Failure to so notify will require that the test be rescheduled.
4. Testing Requirements: Test systems at the same pressure as the duct pressure classification, except positive. Do not exceed maximum air loss of 0.5 percent of rated flow.

3.06 CLEANING

A. Cleaning of Ductwork: Remove debris from ductwork and accessories, and then blow ductwork clean with air movement provided by the system fan or blower. Blow ductwork clean before making final connections to equipment.

B. General Cleaning: Clean up and remove surplus and refuse material, crates, and rubbish arising from Work of this Section from the premises.

END OF SECTION

SECTION 15950
TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes testing, adjusting, and balancing Mechanical systems to produce design objectives, including the following:

1. Balancing airflow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total Mechanical systems to provide indicated quantities.
3. Measuring electrical performance of Mechanical equipment.
4. Setting quantitative performance of Mechanical equipment.
5. Verifying that automatic control devices are functioning properly.
6. Measuring sound and vibration.
7. Reporting results of the activities and procedures specified in this section.

B. Related Sections include the following:

1. Testing and adjusting requirements unique to particular systems and equipment are included in the sections that specify those systems and equipment.
2. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment sections.

1.02 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.

C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

E. Report Forms: Test data sheets for recording test data in logical order.

F. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

G. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

H. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

I. Test: A procedure to determine quantitative performance of a system or equipment.

J. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.

K. AABC: Associated Air Balance Council.

L. AMCA: Air Movement and Control Association.

M. CTI: Cooling Tower Institute.

N. NEBB: National Environmental Balancing Bureau.

O. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.03 SUBMITTALS

A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 2 copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Paragraph below.

B. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3 of this section.

C. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 2 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.

D. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

E. Sample Report Forms: Submit 2 sets of sample testing, adjusting, and balancing report forms.

F. Warranty: Submit 2 copies of special warranty specified in the "Warranty" Paragraph below.

1.04 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by either AABC or NEBB.

B. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Engineer's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, Mechanical controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:
   a. Submittal distribution requirements.
   b. Contract Documents examination report.
   c. Testing, adjusting, and balancing plan.
   d. Work schedule and Project site access requirements.
   e. Coordination and cooperation of trades and subcontractors.
   f. Coordination of documentation and communication flow.

C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

D. Testing, Adjusting, and Balancing Reports: Use testing, adjusting, and balancing Agent's standard forms approved by the Engineer.

E. Instrumentation Type, Quantity, and Accuracy: As described in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

F. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.05 PROJECT CONDITIONS

A. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

1.06 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, Mechanical controls installers, and other mechanics to operate Mechanical systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 7 days advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.07 WARRANTY

A. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. National Project Performance Guarantee: Provide a guarantee on AABC'S "National Standards" forms stating that AABC will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:

C. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified Agent has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
2. Verify that balancing devices, such as flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of Mechanical systems and equipment.

C. Examine project record documents described in Division 1, General Requirements.

D. Examine Engineer's and Engineer's design data, including Mechanical system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about Mechanical system and equipment controls.

E. Examine equipment performance data, including fan and pump curves. Relate performance data to project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce the performance ratings of Mechanical equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems,"

Sections 7 through 10; or in SMACNA's "Mechanical Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification sections have been performed.

G. Examine system and equipment test reports.

H. Examine Mechanical system and equipment installations to verify that indicated balancing devices, such as manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

L. Examine equipment for installation and for properly operating safety interlocks and controls.

M. Examine automatic temperature system components to verify the following:

1. Thermostats located to avoid adverse effects of sunlight, drafts, and cold walls.
2. Sensors are located to sense only the intended conditions.
3. Sequence of operation for control modes is according to the Contract Documents.
4. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
5. Interlocked systems are operating.
6. Changeover from heating to cooling mode occurs according to design values.

N. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.02 PREPARATION

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Automatic temperature-control systems are operational.
3. Equipment and duct access doors are securely closed.
4. Balance, smoke, and fire dampers are open.
5. Windows and doors can be closed so design conditions for system operations can be met.

3.03 GENERAL TESTING AND BALANCING PROCEDURES

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC national standards or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this section. On applicable Sections, perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "Mechanical Systems--Testing, Adjusting, and Balancing" and this section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

C. Mark equipment settings with paint or other suitable, permanent identification-material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.04 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main ducts for accurate duct airflow measurements.

D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

E. Verify that motor starters are equipped with properly sized thermal protection.

F. Check dampers for proper position to achieve desired airflow path.

G. Check for airflow blockages.

H. Check condensate drains for proper connections and functioning.

I. Check for proper sealing of air-handling unit components.

3.05 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems.

B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:
   a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
2. Measure static pressure across each air-handling unit component.
   a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
3. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

4. Adjust fan speed higher or lower than design with the approval of the Engineer. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.

1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating if high-efficiency motor.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.07 HEAT-TRANSFER COILS

A. DX Coils: Measure the following data for each coil:

1. Dry-bulb temperatures of entering and leaving air.
2. Wet-bulb temperatures of entering and leaving air.
3. Airflow.
4. Air pressure drop.

B. Electric-Heating Coils: Measure the following data for each coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperatures at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kW at full load.
6. Fuse or circuit-breaker rating for overload protection.

3.08 TEMPERATURE TESTING

A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive 8-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.09 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Verify free travel and proper operation of control devices such as damper and valve operators.

F. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow measurements. Note the speed of response to input changes.

G. Confirm interaction of electrically operated switch transducers.

H. Confirm interaction of interlock and lockout systems.

I. Record voltages of power supply and controller output. Determine if the system operates on a grounded or nongrounded power supply.

J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.10 TOLERANCES

A. Set Mechanical system airflow rates within the following tolerances:

1. Non-Process Supply, Return, and Exhaust Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: Plus 5 to minus 5 percent.
3. Heating Rate: Plus 5 to minus 5 percent.
4. Cooling Rate: Plus 5 to minus 5 percent.

3.11 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Paragraph above, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to Mechanical systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

   1. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the certified field report data, include the following:

   1. Fan curves.
   2. Manufacturers' test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

   1. Title page.
   2. Name and address of testing, adjusting, and balancing Agent.
   3. Project name.
   4. Project location.
   5. Engineer's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of testing, adjusting, and balancing Agent who certifies the report.
   10. Summary of contents, including the following:
      a. Design versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   11. Nomenclature sheets for each item of equipment.
   12. Notes to explain why certain final data in the body of reports vary from design values.
   13. Test conditions for fan performance forms, including the following:
      a. Settings for outside-, return-, and exhaust-air dampers.
      b. Conditions of filters.
      c. Cooling coil, wet- and dry-bulb conditions.
      d. Face and bypass damper settings at coils.

e. Fan drive settings, including settings and percentage of maximum pitch diameter.
f. Inlet vane settings for variable-air-volume systems.
g. Settings for supply-air, static-pressure controller.
h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.

3. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
4. Unit Data: Include the following:
   a. Unit identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Unit arrangement and class.
   g. Discharge arrangement.
   h. Sheave make, size in inches (mm), and bore.
   i. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
   j. Number of belts, make, and size.
   k. Number of filters, type, and size.
5. Motor Data: Include the following:
   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
6. Test Data: Include design and actual values for the following:
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Filter static-pressure differential in inches wg (Pa).
   f. Preheat coil static-pressure differential in inches wg (Pa).
   g. Cooling coil static-pressure differential in inches wg (Pa).
   h. Heating coil static-pressure differential in inches wg (Pa).
   i. Outside airflow in cfm (L/s).

j. Return airflow in cfm (L/s).
k. Outside-air damper position.
l. Return-air damper position.

F. Apparatus-Coil Test Reports: For apparatus coils, include the following:

1. Coil Data: Include the following:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch (mm o.c.).
   f. Make and model number.
   g. Face area in sq. ft. (sq. m).
   h. Tube size in NPS (DN).
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data: Include design and actual values for the following:
   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outside-air, wet- and dry-bulb temperatures in degrees F (deg C).
   e. Return-air, wet- and dry-bulb temperatures in degrees F (deg C).
   f. Entering-air, wet- and dry-bulb temperatures in degrees F (deg C).
   g. Leaving-air, wet- and dry-bulb temperatures in degrees F (deg C).
   h. Refrigerant expansion valve and refrigerant types.
   i. Refrigerant suction pressure in psig (kPa).
   j. Refrigerant suction temperature in degrees F (deg C).

G. Electric-Coil Test Reports: For electric furnaces, duct coils, variable refrigerant volume units, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data: Include the following:
   a. System identification.
   b. Location.
   c. Coil identification.
   d. Capacity in Btuh (kW).
   e. Number of stages.
   f. Connected volts, phase, and hertz.
   g. Rated amperage.
   h. Airflow rate in cfm (L/s).
   i. Face area in sq. ft. (sq. m).
   j. Minimum face velocity in fpm (m/s).

2. Test Data: Include design and actual values for the following:
   a. Heat output in Btuh (kW).
   b. Airflow rate in cfm (L/s).
   c. Air velocity in fpm (m/s).
   d. Entering-air temperature in degrees F (deg C).
   e. Leaving-air temperature in degrees F (deg C).
   f. Voltage at each connection.
   g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data: Include the following:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches (mm), and bore.
   h. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
2. Motor Data: Include the following:
   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Sheave dimensions, center-to-center and amount of adjustments in inches (mm).
   g. Number of belts, make, and size.
3. Test Data: Include design and actual values for the following:
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Suction static pressure in inches wg (Pa).

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data: Include the following:
   a. System and air-handling unit number.
   b. Location and zone.
   c. Traverse air temperature in degrees F (deg C).
   d. Duct static pressure in inches wg (Pa).

e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Design airflow rate in cfm (L/s).
h. Design velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

J. Instrument Calibration Reports: For instrument calibration, include the following:

1. Report Data: Include the following:
   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

END OF SECTION

Section 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Basic requirements specifically applicable to the work of Division 16 - Electrical Requirements.

B. The Contractor shall furnish equipment, materials, and labor for assembly and installation plus check-out and start-up of the complete electrical system as shown on the Drawings and stipulated in the Specifications.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. As a minimum requirement, the electrical system shall be constructed in accordance with:

1. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), No. 70 - National Electrical Code (NEC).

2. City of Houston Building Code.

3. Other applicable Codes and Standards as referenced in other Master Specifications.

B. Comply with local, county, state and federal regulations and codes in effect as of date of purchase.

C. Equipment of foreign manufacture must meet U.S. codes and standards.

D. Equipment and materials shall conform to requirements of specification and to the criteria provided in data sheets for the project.

1.04 QUALITY ASSURANCE

A. Product Conformance Certificate and Quality Assurance Release. Submit an overall conformance certificate for electrical components signed by the person responsible for product quality. Specifically identify the purchased material or equipment by project

name and location, purchase order number, supplements, and item number where applicable, including materials and services provided by others. Indicate that all requirements have been met and identify any approved deviations.

B. Field Inspection

1. Electrical work shall be inspected and approved by the local code inspectors, the wastewater inspectors, and the Project Manager prior to starting the 7-day test or scheduling training.

2. Contractor shall give a minimum of two days notice to the Inspectors that the installation is ready for inspection and two days notice to the Project Manager.

3. Concealed work shall be inspected and approved by code inspectors and wastewater inspectors before it is covered:

   a. Conduit with stub-ups, underground in duct banks before concrete is poured.

   b. Conduit in slabs, walls and ceilings, complete with boxes.

4. Electrical equipment and materials shall be inspected upon arrival by the Project Manager for compliance with specifications.

1.05 SITE CONDITIONS

A. Take the following site conditions into consideration when fabricating, erecting, installing and wiring electrical equipment under this contract:

1. Plant Location	Houston, Texas	
2. Plant Type and Size		
3. Plant Site Elevation		
4. Seismic Zone	Zone 0	
5. Wind Velocity	90 mph	
6. Temperature, Min./Max.:		
a. Coldest Winter Month	High - 60 degrees F	Low - 41 degrees F
b. Warmest Summer Month	High - 94 degrees F	Low - 73 degrees F
c. Lowest Expected	11 degrees F	

d. Highest Expected 107 degrees F

7. Rainfall:

a. Annual 45 inches

b. Design 3.4 inches/hour, 8.4 inches/24 hours

8. Design Relative Humidity: 98%

9. Station Barometric Pressure:

a. Average Annual 29.5 inches Hg Absolute.

PART 2: PRODUCTS

2.01 COMPONENT DESIGN

A. Components utilized in the construction of the material or equipment shall be of the latest proven design, new and in current production. Do not use obsolete components or components to be phased out of production.

2.02 FACTORY INSPECTION

A. Provide free access with prior notice for the Project Manager at all times to the shop where the material or equipment is being fabricated or tested. Provide reasonable facilities for inspection, witnessing tests, and examining records. Give 7-days notice prior to starting tests which are scheduled for factory inspection.

PART 3: EXECUTION

3.01 PREPARATION

A. Verify dimensions and ratings of equipment and materials to ensure proper fit and performance.

3.02 INSTALLATION

A. Install equipment and materials in accordance with the Drawings and manufacturer's written instructions. If field conditions necessitate changes in electrical installation, obtain approval from the City Engineer.

B. Conductor voltage drop shall not exceed 2 percent for feeders and 3 percent for branch circuits.

3.03 DEMONSTRATION

A. Test the electrical system to specification requirements and to demonstrate correct installation and operation of equipment. O & M Manual shall be furnished prior to testing for reference during testing and corrections for final O & M.

B. Before 7-days test, demonstrate the system to the wastewater inspectors and the Project Manager. Show the system to be fully operational. All alarms, safeties, and communication points to central and locally must operate in both full-automatic and back-up modes. Use fresh water in the test medium.

C. Operate the system continuously for a period of 7 days in full automatic, without failure, to qualify as acceptable. "Failure" is considered any problem that requires correction by maintenance personnel, such as: high or low water level, any motor alarm, power failure, phase failure, communication failure, PLC failure, transducer failure, or UPS failure. This would exclude conditions not under the control of Contractor, such as: evident lightning strikes, 25-year rains, local power utility power failure longer than the specified duration of service from UPS. Failures due to uncontrollable situations would allow the 7-day test to continue, as soon as test conditions are restored and the City Engineer is notified.

D. The existing station shall remain in service during this test.

END OF SECTION

Section 16060

ELECTRICAL DEMOLITION

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Electrical demolition.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. Temporary wiring of systems to maintain operation of facilities while undergoing modifications and demolition shall be provided in accordance with:

1. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), No. 70 - National Electrical Code (NEC), Article No. 590 - Temporary Installations

2. City of Houston Electrical Code.

1.04 SUBMITTALS

A. Annotate existing drawings to sequence the demolition of systems, equipment removal and temporary hook-ups.

B. Schedule with Project Manager for required shut-downs to accommodate system demolition and installation of temporary facilities.

1.05 QUALITY ASSURANCE

A. Verify field measurements and circuiting arrangements are as shown on Drawings.

B. Verify that abandoned wiring and equipment serve only abandoned facilities.

C. Demolition drawings are based on casual field observation and existing record documents. Report discrepancies to City Engineer before disturbing existing installation.

D. By beginning demolition, installer accepts existing conditions and warrants that he will maintain service to equipment and items not scheduled or indicated for removal, and that he will return to the City all items and systems in good operating condition.

PART 2: PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual Sections.

2.02 DESIGN AND CONSTRUCTION

A. The temporary electrical wiring and facilities shall be designed and constructed in strict compliance with NEC - Article No. 590, Temporary Installations and the City of Houston Electrical Code.

PART 3: EXECUTION

3.01 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.

B. Coordinate utility service outages with utility company to provide continuous service to operating equipment.

C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, notify City of Houston Utility Operations and get approval. Use personnel experienced in such operations.

D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from the City Engineer at least one week before partially or completely disabling system. Minimize outage duration.

E. Adding Load to Existing Electrical System: Perform a load analysis to assure that the existing power distribution system (MCC, service, conductors, panel, breakers, feeders, branch circuits, etc.) is not overloaded if additional load is added to existing equipment.

F. Existing electrical conduit and wire may not be reused to feed new equipment except by written authorization from the City of Houston.

3.02 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Remove, relocate, and extend existing installations to accommodate new construction.

B. Remove abandoned wiring to source of supply.

C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. This includes all associated support and anchoring systems. Cut conduit flush with walls and floors, and patch surfaces.

D. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.

E. Disconnect and remove abandoned panelboards and distribution equipment.

F. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

G. Repair adjacent construction and finishes damaged during demolition and extension work.

H. Maintain access to existing installations which remain active. Modify installation or provide access panel as appropriate.

I. Extend existing installations using materials and methods as specified for new work.

3.03 DISPOSAL AND SALVAGE

A. Salvage electrical and instrumentation equipment and wiring size four and larger removed from existing facilities for City's reuse.

B. Material and equipment which can be reused or salvaged remains the property of the City of Houston. Equipment to be retained by the City of Houston shall be delivered to a specified location by the Contractor.

C. Materials and equipment which cannot be reused or salvaged will be removed and disposed by the Contractor.

3.04 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

3.05 INSTALLATION

A. Install relocated materials and equipment under the provisions of Section 02220 - Demolition.

B. Electrical installations and materials shall conform to the current issue of the following standard and codes: American National Standards Institute/National Fire Protection Association (ANSI/NFPA), No. 70 - National Electrical Code (NEC), City of Houston Electrical Code, and material and workmanship.

C. All material shall be free of defects and in safe working condition which will meet electrical classification and functional requirements.

D. Testing shall be made during the course of construction or at the completion of the job. These tests shall be made by the electrical contractor. The contractor shall furnish all test equipment.

E. The job will not be complete until work has been inspected and trial start up has been successfully completed.

END OF SECTION

Section 16111

CONDUIT, FITTINGS, AND BODIES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Conduit, fittings, and bodies.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 RELATED SECTIONS

A. Specification 16195, Electrical Identification.

B. Specification 16402, Underground Duct banks.

1.04 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C 80.1 - Rigid Steel Conduit - Zinc Coated.

2. ANSI C 80.4 - Fittings for Rigid Metal Conduit.

3. ANSI C 80.5 - Rigid Aluminum Conduit.

B. Federal Specifications:

1. W-C-58 C - Conduit Outlet Boxes, Bodies Aluminum and Malleable Iron.

2. W-C-1094 - Conduit and Conduit Fittings Plastic, Rigid.

3. WW-C-566 C - Flexible Metal Conduit.

4. WW-C-581 D - Coatings on Steel Conduit.

C. National Electrical Manufacturers Association (NEMA):

1. NEMA RN 1 - Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing.

2. NEMA TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).

3. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

D. National Fire Protection Association (NFPA), ANSI/NFPA 70 - National Electrical Code (NEC).

E. Underwriters' Laboratories (UL):

1. UL 1 - Flexible Metal Electrical Conduit.

2. UL 6 - Rigid Metal Electrical Conduit.

3. UL 514 B - Fittings for Conduit and Outlet Boxes.

4. UL 651 - Schedule 80 Rigid PVC Conduit.

5. UL 651 A - Type EB and A Rigid PVC Conduit and HDPE Conduit.

6. UL 886 - Electrical Outlet Boxes and Fittings for Use in Hazardous Locations.

7. UL 1684: Reinforced Thermosetting Resin Conduit

F. City of Houston Electrical Code.

1.05 SUBMITTALS

A. Make submittals following Section 01330 - Submittal Procedures:

1. Manufacturer's cut sheets, catalog data.

2. Installation, terminating and splicing procedure.

3. Instruction for handling and storage.

4. Dimensions and weight of products.

5. Code compliance certificate.

6. Conformance certificate.

1.06 QUALITY ASSURANCE

A. Rigid steel conduit shall pass the bending, ductility, and thickness of zinc coating tests described by ANSI C 80.1.

B. Flexible conduit shall pass the tension, flexibility, impact, and zinc coating test described by UL 1.

C. Nonmetallic conduit and fittings shall pass the test requirements of NEMA TC 2, UL 651 and 651 A and Federal Specification W-C-1094 A.

1.07 DELIVERY STORAGE AND HANDLING

A. Package conduit in 10-foot bundles maximum with conduit and coupling thread protectors suitable for indoor and outdoor storage. Package fittings in manufacturer's standard quantities and packaging suitable for indoor storage. Package plastic-coated rigid conduit, fittings, and bodies in such a manner as to protect the coating from damage during shipment and storage.

B. Store conduit above ground on racks to prevent corrosion and entrance of debris.

C. Protect plastic conduit from sunlight.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Rigid Steel Conduit:

1. Allied Tube and Conduit.

2. Triangle Wire and Cable, Inc.

3. Wheatland Tube Company.

B. Rigid Aluminum Conduit:

1. Allied Tube and Conduit.

2. Republic Conduit.

3. Wheatland Tube Company.

C. PVC Coated Steel Conduit:

1. Occidental Coating Company (O-Cal Blue).

2. Robroy Industries, Inc.

a. Rob-Roy Red

b. Plasti-Bond Red

c. Perma-Cote Green

D. PVC Rigid Conduit:

1. Cantex.

2. Carlon Industries, Inc.

E. Conduit Fittings and Bodies:

1. Appleton Electric.

2. Crouse-Hinds.

3. Killark Electric Manufacturing Company.

4. O-Z/Gedney.

F. Epoxy Fiberglass Conduit:

1. Champion Fiberglass.

G. Liquidtight Flexible Conduit:

1. Anamet, Inc.

2. Electriflex Company.

3. Triangle Wire and Cable, Inc.

2.02 MATERIALS AND EQUIPMENT

A. Design Conditions. Use electrical conduit, fittings, and bodies designed for service in areas as specified in Section 16010 - Basic Electrical Requirements and this section to

form a continuous support system for power, control, and instrument cables or any combination thereof.

B. Conduit and Fittings:

1. Rigid Steel Conduit and Fittings.

   a. Rigid steel conduit and rigid steel conduit bends, nipples, and bodies shall be hot-dipped galvanized and shall comply with the latest ANSI C 80.1, UL 6, Federal Specification WW-C-581 D, and NEC Article 346-15.

   b. Mild steel tubing shall be used for conduit, nipples, and couplings, and shall be free of defects on both the inner and outer surfaces.

   c. Fittings and bodies and covers for rigid steel conduit shall be steel or cast-iron and shall comply with ANSI C 80.4, UL 514 B, and Federal Specification W C-58 C.

2. PVC-Coated Rigid Steel Conduit and Fittings

   a. PVC-coated conduit, fittings, bodies, and covers shall conform to NEMA RN 1 (Type A). PVC-coated rigid metal conduit must be UL listed with PVC as the primary corrosion protection. Conduit bodies shall conform to UL 514 B and Federal Specification W C 58 C. PVC-coated fittings for general service locations must be UL listed with the PVC as the primary corrosion protection. Provide sufficient coating for touch-up after installation.

   b. PVC-coated couplings shall be of the ribbed type.

   c. Condulets shall be Form 8, covers shall have encapsulated stainless steel thumb screws.

   d. Condulets and covers shall be of malleable iron or ferroalloy material before coating.

   e. Urethane coating shall be a minimum of 2 mil thickness on the interior of the conduit and the interior of fittings, condulets, covers, and bodies.

3. Liquidtight Flexible Metal Conduit and Fittings

   a. Use liquidtight flexible metal conduit manufactured in accordance with UL 1 and Federal specification WW-C-566 C.

   b. Fittings used with liquidtight flexible metal conduit shall be the PVC-coated type. Thoroughly ground the conduit to the fittings and through the fittings to the box or enclosure to which it is attached.

c. Couplings and fittings for use in hazardous areas shall comply with UL 886, NEC Article 501-4 (a&b), and Federal Specification W-C-586 C.

4. Epoxy Fiberglass Conduit and Fittings

a. Use epoxy fiberglass conduit, bends and fittings which comply with UL 1684 and NEC Article 352 for underground applications.

b. Where used for bends greater than 15 degrees in underground duct bank conduits, provide epoxy fiberglass bends with a deep socket PVC coupling factory attached to each end of each bend.

c. When used for stub-ups, provide an epoxy fiberglass elbow with a vertical epoxy fiberglass nipple to extend the conduit upward to a termination point. Join the elbow to the nipple with an epoxy fiberglass straight socket connection joined with epoxy adhesive. On the top of the epoxy fiberglass nipple, provide an epoxy fiberglass conduit adapter to transition to rigid aluminum conduit. On the underground end of the epoxy fiberglass elbow, provide a factory attached deep socket PVC coupling to transition to Schedule 40 PVC conduit.

d. Epoxy fiberglass conduit shall have a wall thickness of 0.070” for sizes ¾” through and including 4” conduit. A wall thickness of 0.096” shall be provided for 5” epoxy fiberglass conduit.

5. PVC Conduit and Fittings. Use PVC conduit, bends, and fittings, which comply with NEMA TC 2, W-C-A, and NBC Article 347-17 for above ground and underground installation. Conduit shall be Schedule 40.

PART 3: EXECUTION

3.01 PREPARATION

A. Ensure that the conduit system to be installed is sized properly for the cable and wire requirements.

B. Verify the actual physical conduit route from the conduit plan drawings and prepare the conduit support system.

C. Verify the equipment locations to which the conduit will be connected and determine detail requirements for connections.

3.02 INSTALLATION

A. Install PVC-coated conduits in all outdoor locations, inside valve vaults and wet wells, lift station drypits, areas that are not air-conditioned, and in all other corrosive and wet environments. Install PVC-coated conduit in strict accordance with manufacturer's instructions. Use installers certified by the manufacturer.

B. Install rigid aluminum conduits in dry, inside, air-conditioned locations only.

C. Install PVC conduits in reinforced duct banks or encased in concrete slabs. For stub-ups, use PVC coated rigid steel elbows as required in Section 16402.

D. Run exposed conduit parallel or perpendicular to walls, ceilings or main structural members. Group multiple conduits together where possible. Conduit shall not interfere with the use of passageways, doorways, overhead cranes, monorails, equipment removal areas or working areas. In no case shall conduit routing present a safety hazard, trip hazard, or interfere with normal plant operating and maintenance procedures. A minimum overhead clearance of 8 feet shall be maintained in passageways. All conduits installed across walkways shall have concrete or aluminum trip plates installed.

E. Installation and support of conduit shall be from steel or concrete structures in accordance with the standard detail drawings. Furnish necessary conduit straps, clamps, fittings and support for the conduit in accordance with the standard details.

F. Identify conduit at termination points like MCC, light fixtures, control panels, receptacles, panels, and junction boxes.

G. Not more than 3 equivalent 90 degree bends will be permitted between outlets. Provide bonded expansion fittings at building expansion joints.

H. Install conduit runs so that they are mechanically secure, mechanically protected from physical harm, electrically continuous, and neat in appearance. The interiors of conduit shall provide clean, smooth raceways through which conductors may be drawn without damage to the insulation. Make threaded connections wrench tight.

I. Cut conduit square with a power saw or a rotary type conduit cutter designed to leave a flat face. Do not use plumbing pipe cutters for cutting conduit. Ream the cut ends of conduit with a reamer, designed for the purpose to eliminate rough edges and burrs. Threads shall be cut with standard conduit dies providing 3/4-inch taper per foot, allowing the proper length so that joints and terminals may be made up tight and the ends of the conduit not deformed. Keep dies sharp and use a good quality threading oil continuously during the threading operation. Remove metal cuttings and oil from the conduit ends after the threads are cut and paint threads before connections are made. Use non-corrosive Carbozinc No. 11 as manufactured by the Carboline Company, coal tar enamel or zinc rich epoxy primer on the threads of steel conduit before connections are made.

J. Use strap wrenches only to tighten joints in plastic coated rigid steel conduit. Replace all conduit and fittings with damage to the plastic coating, such as cuts, nicks and threader chuck jaw marks. Use a solvent, or the same patching material to seal around the edges of conduit fitting covers.

K. Make changes in direction of conduit using elbows or fittings. Do not use pull boxes to make direction changes unless specifically designated otherwise.

L. Field fabricated bends shall be free of indentations or elliptical sections. The radius of the bend shall not be less than 6 times the smallest diameter of the raceway.

M. Protect all conduit terminations from mechanical injury. Prevent the entry of moisture and foreign matter into the conduit system by properly capping terminations.

N. Avoid trapped runs of conduit, if possible. When they are necessary, provide drainage using a "tee" condulet equipped with a drain. Conduit is likely to pass through areas with a temperature differential of 20 F or more. Seal penetrations with a proper seal fitting at the wall or barrier between such areas. For conduit passing through walls separating pressurized areas from non-pressurized areas, install sealing fittings at the wall on the non-pressurized side.

O. Fit all conduit crossing building or structure expansion joints with approved expansion fittings, except that fittings will not be required when conduit crossing an expansion joint is supported on trapeze hangers in such a way that at no time will the conduit be under stress due to expansion. Unless otherwise indicated on Drawings, install expansion fittings every 300 feet within a straight conduit run and where conduit crosses building expansion joints, using bonding straps to ensure ground continuity. Bonding strap connections shall be protected by minimum 40 mils PVC coating.

P. Where rigid conduit terminates in sheet metal enclosures, fit the conduit with double locknuts and bushings. Sheet metal enclosures made of stainless steel or aluminum located outside or in any other wet, damp, or corrosive areas shall be furnished with PVC-coated threaded hubs. Restrict side penetrations to the lower one third of the enclosure. Where PVC-coated rigid conduit is used, PVC-coated rigid threaded hubs will be used.

Q. Provide flexible Liquidtight metallic conduit where necessary to allow for movement or to localize sound or vibration, at transformers, at motors and any other rotating equipment. Flexible metal conduit shall be used as fixture whips only.

R. Seal all openings or holes where conduits pass through walls or floors. When passing through a firewall or floor, use a fire-rated seal per the typical detail included in the Drawings. Certain walls, as indicated on the drawings, require environmental (air-tight) seals; seal as indicated on the Drawings.

S. Install explosion-proof seals in conduit runs crossing or entering a hazardous classified area (as shown on Drawings). Install type CSBE removable sealing fittings to seal pump cables between wet well and first junction box. If a junction box is not used, install the CSBE seals at the wet well and the control panel.

T. All transitions in PVC-coated conduit size shall be accomplished with PVC-coated RECs or manufactured reducing condulets. RE bushings shall not be used.

U. Parallel runs of conduit may be supported by structural steel racks. When two or more racks are arranged one above the other, provide vertical separation of not less than 12 inches between racks, unless otherwise indicated on Drawings. Space conduits on the racks at least enough to provide 1/4-inch clearance between hubs on adjacent conduits at terminations and to allow room for fittings.

V. Fill conduit racks no more than 75 percent of their capacity, providing usable space for future conduit. To ensure this, conduits leaving the rack horizontally shall be offset up or down so that future conduits may be installed in the space remaining. Construct conduit racks to permit access for wire or cable pulling at all pull points, even when future conduits are added to fill the racks.

W. Where conduit racks are supported on rods from beam clamps or by some other non-rigid suspension system, install rigid supports at no more than 50-foot intervals to give lateral stability to the rack.

X. Conduit racks or hangers must in no way interfere with machinery (or its operation), piping, structural members, process equipment, or access to anticipated future equipment. Refer to architectural, structural, equipment layout and piping drawings to ensure that this requirement is met. Label high voltage conduit with the circuit phase-to-phase voltage by means of a firmly attached tag or label of approved design at each conduit termination, on each side of walls or barriers pierced and at intervals not exceeding 200 feet along the entire length of the conduit.

Y. Support conduit sizes 2 inches and larger at spacings not exceeding 10 feet and conduit sizes 1-1/2 inches and smaller at spacings not exceeding 8 feet.

Z. The means of fastening conduit to supports shall be: by one hole malleable iron conduit straps secured by wood screws to wood and by bolts with expansion anchors to concrete or masonry; by "Korn" clamps or U-bolts to other surfaces. Use "clamp backs" when strapping conduits to walls, column faces, or other such surfaces.

AA. Support conduit runs with conduit clamps, hangers, straps and metal framing channel attached to structural steel members. Conduits of 1-1/2 inch size or less may be supported by one-hole conduit straps on concrete, tile or steel work, but for larger size conduit, 2-hole straps shall be used. Use clamps of galvanized malleable iron for rigid

galvanized conduit and stainless steel for PVC-coated conduit. Metal framing channel straps used for PVC-coated conduit shall be type 316 stainless steel.

BB. Install conduits supported form building walls with at least 1/4-inch clearance from the wall to prevent the accumulation of dirt and moisture behind conduit.

CC. All Conduits embedded in concrete lift station deck shall be PVC-coated rigid.

END OF SECTION

Section 16120

600-VOLT BUILDING WIRE AND CABLE

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specifications for 600-volt building wire and cable.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA 70 - National Electrical Code (NEC), Article 310 - Conductors for General Wiring

B. Underwriter's Laboratories (UL)

1. UL 83: Thermoplastic Insulated Wires and Cables

2. UL 1063: Machine Tool Wires and Cables

C. American Society for Testing and Materials (ASTM)

1. ASTM B 3: Soft or Annealed Copper Wires

2. ASTM B 8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft

D. Insulated Cable Engineers Association (ICEA), ICEA S-61-402: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-5)

E. City of Houston Electrical Code

1.04 SUBMITTALS

A. Make submittals following Section 01330 - Submittal Procedures.

1. Manufacturer's cut sheets, catalog data

2. Instruction for handling and storage

3. Dimensions and weight

4. Conformance certificate

1.05 QUALITY ASSURANCE

A. Tests. Cable shall meet all the requirements of Part 6 of ICEA S-61-402.

B. Conformance Certificate and Quality Assurance Release: Submit a conformance certificate signed by the person responsible for product quality. The certificate shall specifically identify the purchased material or equipment; such as by the project name and location, purchase order number, supplements, and item number where applicable, including materials and services provided by others. The certificate shall indicate that requirements have been met and identify any approved deviations.

1.06 DELIVERY, STORAGE AND HANDLING

A. Ship wire and cable on manufacturer's standard reel sizes unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Each reel shall contain one continuous length of cable. Provide impact protection by wood lagging or suitable barrier across the traverse of the reel. Provide moisture protection by using manufacturer's standard procedure or heat shrinkable self-sealing end caps applied to both ends of the cable.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. American Insulated Wire Corporation

B. Carol Cable Company, Inc.

C. General Cable Company

D. Okonite Company

E. Rome Cable Company

F. Triangle Wire and Cable, Inc.

2.02 MATERIALS AND EQUIPMENT

A. Design. Provide cable designated as XHHW-2 stranded single conductor type and UL 83 and UL 1063 listed, rated 600 volts and certified for continuous operation at maximum conductor temperature of 90 C in dry locations and 75 C in wet locations in conduit. MTW stranded will be used in control panels.

B. Conductors. Provide conductors which are Class B, concentric stranded, annealed uncoated copper with physical and electrical properties complying with ASTM B 3 and ASTM B 8 and Part 2 of ICEA S-61-402.

C. Insulation. Each conductor shall be PVC insulated and nylon jacketed to meet the requirements of Part 3 of ICEA S-61-402. The insulation thickness shall match the dimensions listed in Table 310-13 of the National Electrical Code (NEC) for type XHHW-2 wire.

D. Wire Marking

1. Wire marking shall be in accordance with National Electrical Code (NEC) Article 310-11 and shall be printed on the wire insulation at 2-foot intervals.

2. The printing method used shall be permanent and the color shall sharply contrast with the jacket color.

E. The single conductor color coding shall be as follows:

System Voltage	A	B	C	Neutral
120/208 Volt 3Ph/4w	Black	Red	Blue	White
120/240 Volt 3Ph/4w	Black	Orange	Blue	White
277/480 Volt 3Ph/4w	Brown	Purple	Yellow	Grey
Motor Control	1	Black		
	2	Red		
	3	Blue		
Ground		Green		

PART 3: EXECUTION

3.01 PREPARATION

A. Complete the cable raceway systems and underground duct banks before installing cables.

B. Verify sizing of raceways and pullboxes to ensure proper accommodation for the cables.

C. Check the length of the cable raceway system against the length of cable on the selected reel.

D. Clean conduits of foreign matter before cables are pulled.

3.02 INSTALLATION

A. Wiring Methods

1. Use wiring methods indicated on Drawings.

2. In general, use XHHW-2 stranded building wire for lighting, power and control wiring where conductors are enclosed in raceways like in above ground conduit system or in underground duct banks, or inside control panels.

3. Do not use solid conductors.

4. Use conductors not smaller than No. 12 AWG stranded for general lighting circuits.

5. Use conductors not smaller than No. 14 AWG stranded for control circuits, except when part of a multiconductor cable or internal panel wiring.

6. In general, do not splice conductors unless approved by the City Engineer.

7. Splices associated with taps for lighting and control circuits are allowed without approval.

8. Make splices in accessible junction boxes.

B. Single Conductor in Conduit and Ductbank

1. Install cables in accordance with the manufacturer's instructions and the National Electrical Code (NEC), Chapter 3- Wiring Methods and Materials. Do not exceed maximum wire tension, maximum insulation pressure and minimum bending radius.

2. Pull cables into conduits using Polywater J pulling compound.

C. Single Conductor in Cable Tray (NOT USED)

D. Preparation for Termination

1. Make 600-volt insulated conduit terminations and splices with heat shrinkable sleeves and seals.

2. Terminal lugs and connectors for all sizes of conductors shall be crimp-on type.

3. For size 1/0 AWG and larger, crimp-on lugs shall have the long barrel with 2-hole tongues except in places where termination space is limited.

E. Tests

1. In general, test insulation integrity of the wiring system before terminating.

2. Make sure to disconnect sensitive electronic equipment before testing insulation.

3. Use a 500 VDC megohmmeter and perform the wire system insulation test in accordance with the operating instructions.

F. Termination. After the 600-volt wiring system has been tested with satisfactory results, reconnect wire.

END OF SECTION

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Section 16126

INSTRUMENTATION CABLE

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specifications for instrumentation cable.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM).

1. ASTM B3: Soft or Annealed Copper Wires.

2. ASTM B8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft.

3. ASTM B33: Tinned Soft or Annealed Copper Wire for Electrical Purposes.

B. Institute of Electrical and Electronics Engineers (IEEE), IEEE 383-2.5: IEEE Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

C. Insulated Cable Engineers Association (ICEA).

1. ICEA S-61-402: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-5).

2. ICEA S-66-524: Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-7).

3. ICEA S-68-516: Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-8).

D. Underwriters' Laboratories (UL).

1. UL 44: Rubber Insulated Wires and Cables.

2. UL 83: Thermoplastic Insulated Wire and Cables.

E. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA No. 70 - National Electrical Code (NEC), Chapter No. 3 - Wiring Methods and Materials, Article 725 - Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power-Limited Circuits.

1.04 SUBMITTALS

A. Submit the following under the provisions of Section 01330 – Submittal Procedures:

1. Completed engineer's data sheets from this specification or manufacturer's data sheets, cut sheets, and catalog data.

2. Installation, terminating and splicing procedure (including bending radius and pulling tension data).

3. Instruction for handling and storage.

4. Dimensions and weight.

1.05 QUALITY ASSURANCE

A. Tests

1. Cable shall be tested at the factory to confirm that the cable complies with requirements of ICEA Section 7.7.9 of S-66-524 or 7.5.9 of S-68-516.

2. Where applicable, the cable shall meet the requirements of the vertical tray flame test as described in IEEE 383-2.5.

1.06 DELIVERY, STORAGE AND HANDLING

A. Ship cable on manufacturer's standard reel sizes unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Each reel shall contain one continuous length of cable. Reels shall be of the type specified on the data sheets. Provide impact protection by wood lagging or suitable barrier across the traverse of the reel. Provide moisture protection by manufacturer's standard procedure or heat shrinkable self-sealing end caps applied to both ends of the cable.

PART 2: PRODUCTS

2.01 MANUFACTURERS

A. Alpha Wire Corporation

B. Belden Division, Cooper Industries, Inc.

C. Cablec Continental Cables Company

D. General Cable Company

E. Manhattan Electric Cable Corporation

F. Okonite Company

2.02 MATERIALS AND EQUIPMENT

A. Design. Provide cable with the following design characteristics. The cable shall consist of multiple conductors. The cable assembly shall be UL listed, flame, oil and sunlight resistant, and certified for continuous operation in wet or dry locations while installed in underground duct, conduit, or cable tray. The number and size of conductors supplied in each cable shall correspond to requirements of this project. Each conductor shall be individually insulated. Pairs and triads shall have conductors which are twisted together with a drain wire, shielded, and covered with a jacket. Multi-pair/triad cables shall consist of the required number of electrically isolated, shielded pairs or triads, which are bundled together and covered by an overall jacket.

B. Conductors. Provide conductors which are Class B, concentric stranded, annealed tinned copper.

C. Insulation. Each conductor shall have 600-volt insulation.

D. Drain Wire. Provide drain wire which is Class B, seven-strand, tin-coated copper. The drain wire shall not be less than two AWG sizes smaller than the insulated conductor's size, except for multiple pair/triad drain wires, which shall not be less than the insulated conductor size.

E. Shielding. Provide shielding consisting of laminated, nonburning, mylar-backed aluminum tape applied helically around a twisted pair or triad with the aluminum side in continuous contact with the drain wire. Wrap the tape around each twisted pair or triad with a 25 percent minimum.

F. Jacket. The jacket shall be PVC.

G. Armor. Where indicated on Project Drawings, install instrumentation cables protected by an interlocked metal tape armor coating made of galvanized steel.

H. Conductor Identification. Use individual conductors in single-pair and single-triad cables which are color coded black and white; and black, white and red, respectively. Multi-pair triad cables shall have one conductor in each pair or triad colored white, and all other conductors are color coded in sequence according to Table L-2 of Appendix 2 of ICEA S 66-524.

I. Cable Marking. Print cable marking information on the jacket of each cable at 2-foot intervals. Use a permanent printing method with color sharply contrasting the jacket color.

PART 3: EXECUTION

3.01 PREPARATION

A. Complete cable raceway systems, underground duct banks and cable support systems before installing cables.

B. Verify sizing of raceways and pullboxes to ensure proper accommodation for the cables.

C. Check the length of the cable raceway system against the length of cable on the selected reel.

D. Do not install or work on PVC insulated or jacketed cables in temperatures below 32 degrees F.

E. Clean conduits of foreign matter before cables are pulled.

F. Provide at least 30 percent spare conductors or pairs.

3.02 INSTALLATION

A. Cable in Conduit and Ductbank

1. Install cables in accordance with the manufacturer's instructions and NEC Article 725 - Class 1, Class 2, and Class 3 Remote Control, Signaling and Power Limited Circuits. Do not exceed maximum wire tension, maximum insulation pressure and minimum bending radius.

2. Pull cables into conduits using Polywater J pulling compound.

B. Cable in Tray. (NOT USED)

C. Termination

1. Do not splice conductors. For termination use crimp-on type ring tongue non-insulated tin plated copper lugs.

2. For shielded control cable, terminate the shield and ground it at one end only, preferably at the control panel end for instrument and communication cable and at the supply end for electronic power cables.

3. If splicing is required, maintain shield continuity by jumpering the ground shield across connection point where it is broken at junction boxes, or other splice points. Insulate these points from ground.

4. Mark wiring on both ends with circuit numbers or loop tag numbers. Heat shrink wire markers after the ring tongue terminal has been installed. Extend the marker over the crimp or base of the terminal.

D. Tests

1. Before connecting the cables, test insulation integrity and conductor continuity.

2. Use a 500 VDC megohmmeter and perform the cable insulation test in accordance with the operating instructions.

E. Termination. After the 600-volt instrumentation cable has been tested with satisfactory results, the cable can be terminated at both ends to their designated terminal points.

END OF SECTION

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Section 16131

DEVICE, PULL AND JUNCTION BOXES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specifications for device, pull, and junction boxes.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA).

1. FB1 - Fittings and Support for Conduits and Cable Assemblies

2. 250 - Enclosures for Electrical Equipment (1000 volts maximum)

B. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA70 - National Electrical Code (NEC) - Article 314 - Outlet Device, Pull and Junction Boxes, Conduit Bodies and Fittings.

C. Underwriters Laboratories (UL):

1. 50 - Safety Cabinets and Boxes

2. 508 - Safety Industrial Control Equipment

3. 514B - Safety Fittings for Conduit and Outlet Boxes

4. 886 - Safety Outlet Boxes and Fittings for Use in Hazardous Areas

1.04 SUBMITTALS

A. Submit the following under provisions of Section 01330 – Submittal Procedures:

1. Manufacturer's cut sheets, catalog data

2. Instruction for handling and storage

3. Installation instructions

4. Dimensions and weights

1.05 DELIVERY, STORAGE AND HANDLING

A. Pack and crate boxes to permit ease of handling and to provide protection from damage during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Pull and Junction Boxes

1. Hoffman Industrial Products

2. Pauluhn Electric Manufacturing Company

3. Hennessy

4. Tanco

5. Tejas

6. Circle A.W.

B. Cast Device Boxes

1. Appleton Electric Company

2. Crouse-Hinds, Division of Cooper Industries

3. Killark Electric Manufacturing Company

2.02 MATERIALS AND EQUIPMENT

A. Pull and Junction Boxes

1. Provide UL-approved junction boxes and pull boxes manufactured from type 316 stainless steel sheet metal and meeting requirements of NEMA 4X for corrosive and wet area, NEMA 250 and NEC Article 314.

2. Provide boxes with a type 316 stainless steel continuous hinge, closure hasps and all-stainless steel hardware. Junction boxes shall be mounted so the door opens to the right or to the left.

3. Furnish the door with neoprene gasket and provision for padlock.

B. Device Boxes

1. Provide UL-approved boxes designed and manufactured to house electrical devices like receptacles and switches, and in conformance with NEMA FB1 and NEC Article 314.

2. Supply boxes that are hot-dip galvanized on cast iron suitable for corrosive and wet atmosphere.

C. Hardware

1. Mounting Hardware: Stainless steel

2. Conduit Connectors: Watertight as manufactured by Myers Hubs, or equal.

PART 3: EXECUTION

3.01 PREPARATION

A. Review the drawings and determine how many boxes of each kind are required and check if supplied quantity is sufficient.

3.02 INSTALLATION

A. Boxes described in this specification shall be used both in dry and wet, corrosive areas, both inside and outside locations.

B. Install boxes in accordance with NEC Article 314 in locations indicated on the Drawings. Junction boxes shall be mounted so the door opens to the right or to the left.

C. Install junction and pull boxes in readily accessible places to facilitate wire pulls, maintenance and repair. Junction boxes shall be sized for the number and size of conduits that enter the junction box.

D. Plug unused conduit openings.

E. Make conduit connections to sheet metal boxes with watertight conduit connectors.

F. Label boxes with phenolic nameplates as required in Section 16195.

END OF SECTION

Section 16140

WIRING DEVICES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specifications for wiring devices including:

1. Receptacles.

2. Wall switches.

3. Wall plates and cover plates.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA):

1. NEMA WD1 - General Purpose Wiring Devices.

2. NEMA WD6 - Dimensional Requirements.

B. Federal Specifications (WC-596F).

C. American National Standards Institute/National Fire Protection Association (NFPA):

1. NFPA No. 70 - National Electrical Code (NEC), Articles 210 Branch Circuits, 250 Grounding and 410, Paragraphs 56, 57 and 58.

1.04 SUBMITTALS

A. Submit the following under provisions of Section 01330 – Submittal Procedures:

1. Product Data: Manufacturer's product literature and specifications including dimensions, weights, certifications and instructions for handling, storage and installation.

1.05 DELIVERY, STORAGE AND HANDLING

A. Pack and crate devices to permit ease of handling and protect from damage during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Hubbel Inc. Wiring Devices Division

B. Pass & Seymour/Legrand.

2.02 MATERIALS AND EQUIPMENT

A. Standards: Conform to NEMA WD1 for general requirements and NEMA WD6 for dimensional requirements.

B. Manufacture devices to heavy-duty industrial specification grade with brown nylon bodies (orange for isolated-ground receptacles) back and side wiring provisions and green-colored grounding screws.

C. Receptacles:

1. Duplex-type receptacles: Rated 20 amps at 120 volts.

2. Contacts: Brass or phosphor bronze.

3. Receptacle grounding system: Extend to the mounting strap unless isolated ground is indicated or required.

4. GFI or GFCI (ground fault circuit interrupter) receptacles: Provide feed-through type with test and reset button.

D. Wall Switches:

1. Toggle switches: Rated 20 amps at 120/277 volts AC rated for both resistive and inductive loads.

2. Contacts: Silver cadmium oxide construction to prevent sticking, welding and excessive pitting.

E. Cover Plates:

1. In outdoor, corrosive and wet areas, provide cover plates of heavy duty plastic, gasketed with hinged covers that remain waterproof while still in use and stainless steel hardware.

2. All other plates: Type 302 stainless steel.

PART 3: EXECUTION

3.01 PREPARATION

A. Verify that device boxes are correctly placed.

B. Verify that the correct quantity, size and type of wires are pulled to each device box.

C. Verify that wiring has been checked at both ends.

D. Prepare wire ends for connection to devices.

E. Inspect each wiring device for defects.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install devices plumb and level.

C. Install switches with OFF position down, and the centerline of the switch at 48” above the flow.

D. Install receptacles with grounding pole on top, and the centerline of the receptacle at 18” above the flow.

E. Connect wiring device grounding terminal to outlet box with bonding jumper.

F. Connect wiring devices by wrapping conductors clockwise around screw terminals.

G. Install cover plates on switch, receptacle and blank outlets in finished areas.

H. Energize and test devices for proper operation.

END OF SECTION

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Section 16161

PANELBOARDS

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specifications for panelboards.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA)

1. NEMA AB1: Molded Case Circuit Breakers

2. NEMA PB1: Panelboards

3. NEMA PB1.1: Instruction for Safe Installation Operation and Maintenance of Panelboards rated 600 volts or less.

4. NEMA PB1.2: Application Guide for Ground-fault Protective Devices for Equipment

B. Federal Specifications, FS W-C-375A: Circuit Breakers, Molded Case, Branch Circuit and Service.

C. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA No. 70 - National Electrical Code (NEC), Article 408 - Switchboards and Panelboards.

1.04 SUBMITTALS

A. Submit the following under provisions of Section 01330 – Submittal Procedures:

1. Manufacturer's cut sheets and catalog data

2. Breaker arrangement

3. Breaker characteristic curves

4. Instruction for handling and storage

5. Installation instructions

6. Dimensions and weights

1.05 DELIVERY, STORAGE AND HANDLING

A. Have panelboards packed and crated to permit ease of handling and to provide protection from damage during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Eaton.

B. General Electric

C. Square D Company

2.02 MATERIALS AND EQUIPMENT

A. Basic Requirements

1. Use panelboards manufactured and tested in accordance with NEMA PB 1.

2. Provide circuit breakers of industrial grade, manufactured and tested in accordance with NEMA AB 1 and Federal Specification FS W-C-375.

3. Do not exceed 42 available single pole branch circuits in any one panelboard.

4. Perform a load analysis to assure the panel rating is not overloaded when new loads are added to existing panels.

B. Rating

1. Voltage rating, current rating, number of phases, number of wires and number of poles are indicated on Drawings.

2. Branch circuit breaker interrupting capacity shall be minimum 10,000 ampere RMS symmetrical for 208V; 35,000 ampere RMS symmetrical for 480V.

C. Circuit Breakers: Molded case, bolt-on thermal magnetic type with number of poles and trip ratings as shown on the Drawings. Provide ground fault interrupters with trip rating where shown on the Drawings.

D. Bus System

1. Bus Bars: 98 percent conductivity copper. Provide a solid neutral bar in 4-wire panelboards. Include ground bus in all panels. Provide split-bus panels where shown on Drawings.

2. Main: Circuit breaker or main lugs only as indicated on the Drawings or as required to meet the current interrupting ratings.

E. Box and Trim

1. Construction: Door-in-door construction with Code grade steel, ample gutter space, flush door, flush snaplatch and lock.

2. Trim: Surface or flush as required. Enclose panelboards located outdoors, or in other wet and corrosive areas in NEMA 4X type 316 stainless steel enclosures. Enclose indoor panelboards installed in air conditioned areas in a NEMA 1 enclosure with manufacturer's standard gray enamel finish.

3. Directory: Typed card, with glass cover in frame on back of door giving the circuit numbers and the area or equipment served.

F. Conduit Connectors: Watertight as manufactured by Myers Hubs, or equal.

PART 3: EXECUTION

3.01 PREPARATION

A. Review Drawings to verify that panelboards are correct for the application.

3.02 INSTALLATION

A. Install the panelboard in accordance with NEMA PB 1.1 and NEC Article 408.

B. Where possible, mount panelboards 6'-0" (to top of cabinet) above finished floor or grade. In wet and corrosive areas, including outdoor locations, install panel enclosures on spacers to provide approximately 1/4-inch between back of cabinet and mounting surface. Mounting hardware shall be type 316 stainless steel.

C. In wet and corrosive areas, including outdoor locations, connect conduit to the bottom of enclosure and to the lower 30 percent of the sides using watertight connectors.

END OF SECTION

Section 16165

DISCONNECT SWITCHES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specifications for disconnect switches including:

1. Fusible disconnect switches

2. Non-fusible disconnect switches

3. Fuses

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA)

1. NEMA KS1: Enclosed Switches

B. Underwriters Laboratories (UL)

1. UL 98: Standard for safety enclosed switches and Dead Front Switches

2. UL 198C: High Interrupting Capacity Fuses, Current Limiting type

3. UL 198E: Class R Fuses

C. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA No. 70 - National Electrical Code (NEC), Chapter 4.

1.04 SUBMITTALS

A. Submit the following under provisions of Section 01330 – Submittal Procedures:

1. Manufacturer's cut sheets and catalog data
2. Switch internal arrangement
3. Fuse characteristic curves
4. Instructions for handling and storage
5. Installation instructions
6. Dimensions and weights

1.05 DELIVERY, STORAGE AND HANDLING

A. Have disconnect switches packed and crated to permit ease of handling and to provide protection from damage during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Disconnect Switches:

1. Eaton
2. General Electric
3. Square D Company

B. Fuses

1. Bussman Division, Cooper Industries
2. Gould Shawmut
3. Littelfuse Incorporated

2.02 MATERIALS AND EQUIPMENT

A. Disconnect Switches

1. Characteristics: Horsepower rated, 600-volt, heavy-duty type with an interlocked door, positive quick-make, quick-break mechanism and visible blades.

2. Use switches and components designed, manufactured and tested in accordance with NEMA AB1, NEMA KS1, UL 98, and NEC Chapter 4.

3. Enclose switch in a NEMA 12 type enclosure for indoor, air-conditioned applications and NEMA 4X (type 316 stainless steel) in outdoor locations, non air-conditioned areas, or other wet or corrosive areas.

4. Provide switches with provisions for padlocking the operating lever in OFF position and door in closed position.

5. Select switches having the number of poles and general size conforming to the Drawings.

6. Conform to fusible, non-fusible or circuit breaker type switch requirements as shown on Drawings and required by the NEC, or one-line diagrams.

7. Provide an auxiliary contact, shown on the Drawings.

8. Select fuses or circuit breakers with current interrupting duty as calculated for the points of switch application or as indicated on the Drawings or one-line diagrams.

B. Fuses. Unless otherwise noted on Drawings, for fuses used in disconnect switches, provide the dual-element, time-delay type with the maximum interrupting rating of 200,000 amperes, conforming to the NEC.

C. Conduit Connectors: Watertight as manufactured by Myers Hubs, or equal.

PART 3: EXECUTION

3.01 PREPARATION

A. Review the Drawings and verify that the disconnect switches are correct for the applications.

B. Make sure that the correct fuses or breakers are being used regarding size and short circuit interrupting capability.

C. Prepare adhesive labels on the inside door of each switch indicating UL fuse class and size or breaker type and size for replacement.

3.02 INSTALLATION

A. Install the disconnect switches in accordance with and NEC Chapter 4. Disconnect switches shall be mounted in sight of or within 25’ of motors and rotating equipment.

B. Where possible, mount switches 6'-6" (to top of cabinet) above finished floor or grade.

C. In wet and corrosive areas, including outdoor locations, install switches on spacers to provide a space of approximate 1/4-inch between the back of cabinet and the mounting surface.

D. In wet and corrosive areas, including outdoor locations, connect conduit to the bottom of enclosure and to the lower 30 percent of the sides using watertight connectors.

E. Disconnect shall be labeled as required in Section 16195.

END OF SECTION

Section 16170

GROUNDING AND BONDING

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Grounding electrodes and conductors

B. Equipment grounding conductors

C. Bonding

D. Power system grounding

E. Communication system grounding

F. Electrical equipment and raceway grounding and bonding

G. Control equipment grounding

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM B3: Soft or Annealed Copper Wires

2. ASTM B8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft

3. ASTM B33: Tinned Soft or Annealed Copper Wire for Electrical Purposes

B. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 142-82: Recommended Practice for Grounding of Industrial and Commercial Power Systems

2. IEEE 383-2.5: IEEE Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

C. Underwriters' Laboratories (UL)

1. UL 83: Thermoplastic Insulated Wire and Cables

2. UL 467: Grounding and Bonding Equipment

D. National Fire Protection Association (NFPA), NFPA No. 70 - National Electrical Code (NEC), Article No. 250 - Grounding.

1.04 SUBMITTALS

A. Submit the following under the provisions of Section 01330 – Submittal Procedures:

1. Manufacturer's cut sheets and catalog data

2. Installation, terminating and splicing procedure

3. Instruction for handling and storage

4. Dimensions and weight

1.05 QUALITY ASSURANCE

A. Tests

1. Use insulated cable conforming to requirements of the vertical tray flame test as described in IEEE 383-2.5.

2. Test grounding system in the field in accordance with procedures outlined in Part 3 - Execution.

1.06 DELIVERY, STORAGE AND HANDLING

A. Ship grounding cable on manufacturer's standard reel sizes unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Each reel shall contain one continuous length of cable. Provide impact protection by wood lagging or suitable barrier across the traverse of the reel. Pack and crate other materials specified to withstand normal abuse during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Cable

1. American Insulated Wire Company
2. Cablec Continental Cables Company
3. General Cable Company
4. Okonite Company
5. Pirelli Cable Corporation
6. Rome Cable Corporation
7. Triangle Wire and Cable, Inc.

B. Ground Rods and Connectors:

1. Blackburn
2. Copperweld
3. Thomas & Betts

C. Exothermic Connections:

1. Burndy Corporation (Therm-O-Weld)
2. Erico Products (Cadweld)

D. Grounding Connectors:

1. Burndy Corporation
2. O.Z. Gedney
3. Thomas & Betts

2.02 MATERIALS AND EQUIPMENT

A. Design. Provide grounding cable and materials with the following characteristics:

1. Use a grounding system designed in accordance with NEC Article No. 250 Grounding, and the IEEE 142-82 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.

B. Materials

1. Use grounding conductors, bare or insulated, which are manufactured and tested in accordance with applicable standards ASTM B3, ASTM B8 and ASTM B33.

2. Where indicated on Project Drawings, provide grounding conductors of No. 4/0 AWG, Class C stranded, bare copper cable. :

3. Where single conductor insulated grounding conductors are called for, use 600 volt insulation. Use ground conductors identified with green insulation or green tape marking.

4. Supply identifying ribbon which is PVC tape, 3 inches wide, red color, permanently imprinted with "CAUTION BURIED ELECTRIC LINE BELOW" in black letters as specified in Section 16195, Electrical Identification.

PART 3: EXECUTION

3.01 PREPARATION

A. Complete site preparation and soil compaction before trenching for grounding connectors and driving ground rods.

B. Verify from Drawings the exact location of stub-up points for grounding of equipment.

3.02 CONSTRUCTION CRITERIA

A. The main grounding conductors shall be installed at a depth of at least 30 inches below earth surface. Connect the grounding conductors to ground rods and to tap connections to form a grounding system as indicated on the electrical Drawings. The Contractor shall give special attention to the grounding of service equipment and shall comply with the NEC, local authorities and the serving utility company.

B. Electrical equipment, buildings, and other equipment shall be grounded as indicated on the Drawings. Where ground rods are required, the rods shall be 20 feet long, 3/4 inch

diameter, copper-clad steel ground rods. Rods shall be driven vertically, and the top of the rods shall be a minimum of 12 inches below finished grade, or as specified on the Drawings. Ground test wells shall be provided where indicated in the Drawings.

C. Local pushbutton and selector switch stations, two-wire control devices, disconnect switches, lighting transformers, panelboards, operator panels, benchboards, and the enclosures of other electrical apparatus shall be grounded through an equipment grounding conductor run with the power supply or control circuit conductors or shall be grounded as shown on the Drawings.

D. Ground medium voltage motors, in addition to the grounding conductors in the motor feeder cable, with a separate No. 4/0 AWG cable to motor frame.

E. Motors having power supplied by multiconductor cable shall be grounded by a separate grounding conductor in the cable and where supplied by single conductor cable in conduit by a grounding conductor pulled in the conduit. Connect ground conductors to the ground bus in the motor control center and to the ground terminal provided in the motor conduit box.

F. Do not ground the insulated bearing pedestals of large motors.

G. Connect ladder-type cable trays to the grounding electrode system.

H. Install a warning ribbon approximately 12 inches below finished grade directly above the main grounding conductors.

3.03 INSTALLATION

A. Equipment Grounding

1. Make grounding connections to surfaces which are dry and cleaned of paint, rust, oxides, scales, grease and dirt to ensure good conductivity. Clean copper and galvanized steel to remove oxide before making welds or connections.

2. Use the exothermic welding process for below-grade grounding connections, except at ground rods. Use mechanical connectors or thermal connections for above-grade grounding connections as shown on the Drawings.

3. Make grounding connections to electrical equipment, vessels, mechanical equipment and ground rods in accordance with the Drawings.

4. Ground tanks and vessels by making connections to integral structural supports or to existing grounding lugs or pads, and not to the body of the tank or vessel.

5. Leave ground connections to equipment visible for inspection. Protect them with PVC non-metallic conduit as indicated on the Drawings.

6. Make connections to motor frames and ground buses with lugs attached to the equipment by means of bolts. Do not use motor anchor bolts or equipment housing for fastening lugs of grounding cable.

7. Where the wiring for lighting systems consists of single conductor cables in conduit, provide each conduit with an equipment grounding conductor. Use a grounding conductor with green colored insulation and ground equipment in the lighting system.

B. Raceway and Support Systems Grounding

1. Install raceway, cable rack or tray and conduit so that it is bonded together and permanently grounded to the equipment ground bus, according to the Drawings. Connection to conduit may be grounding bushing or ground clamp.

2. Install raceway at low voltage motor control centers or other low voltage control equipment so that it is bonded and grounded, except that any conduit which is effectively grounded to the sheet metal enclosure by bonding bushing or hubs need not be otherwise bonded.

3. Where a grounding conductor is run in or on a cable tray, bond the grounding conductor to each section of cable tray with a cable tray ground clamp.

4. Where only a grounding conductor is installed in a metal conduit, bond both ends of the conduit to the grounding conductor.

5. Provide flexible "jumpers" around raceway expansion joints. Use copper bonding straps for steel conduit. Install jumpers across cable tray joints which have been parted to allow for expansion and any hinged cable tray connections.

C. Fences and Gates. Ground fences, fence posts and gates to the underground grounding conductor system only when shown on the Drawings.

D. Power System Grounding

1. Solidly ground the secondary neutral of the main power supply transformer either to the grounding system or through an impedance. See Drawings for details.

2. Solidly ground the neutral of lighting, instrument and control transformers.

E. Cable Armor and Shields

1. For shielded control cable, terminate and ground the shield at one end only, preferably at the control panel end for instrument and communication cable and at the supply end for electronic power cables. Maintain shield continuity by jumpering the ground shield across connection point where it is broken at junction boxes, or other splice points. Insulate these points from ground.

2. Connect the ground wire in power cable assemblies at each terminal point to a ground bus, if available, or to the equipment enclosure. Do not carry these ground wires through a "doughnut" current transformer (CT) used for ground fault relaying; do carry ground leads from stress cones through CTs. Ground power cable armor and shield at each terminal point.

F. Test Wells

1. Provide access (test wells) for testing the ground grid system at one or several ground rod locations as indicated on the Drawings. Make test wells of a pipe surrounding the rod and connections with a cover placed on top at grade level. See Drawings for details.

2. Install a test well at the service entrance pole to serve as the service entrance grounding electrode.

G. Test

1. Perform ground resistance tests after underground grounding system installation and connections are complete.

2. Make tests at each ground test well using a "fall of potential" test method. Each ground test well shall not exceed a maximum resistance of 5 ohms. Where measured values exceed this figure, install additional ground rods as required to reduce the resistance to the specified limit.

H. Inspection. Inspection of the grounding system by the Project Manager and the local Code Inspector must take place before trenches with grounding system cables are backfilled.

END OF SECTION

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Section 16171

LOW VOLTAGE MOTORS

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specification for low voltage motors.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be provided for work performed under this Section. Include the cost for this work in the lump sum base bid.

B. Refer to Section 01270 – Measurement and Payment.

1.03 RELATED WORK

A. Section 16195 – Electrical Identification.

B. Section 01330 – Submittal Procedures.

C. Section 01340 – Shop Drawings, Product Data, and Samples.

D. Section 01782 – Operations and Maintenance Data.

E. Section 11311 – Submersible Wastewater Pumps

1.04 REFERENCES

A. American National Standards Institute/Anti-Friction Bearing Manufacturers Association (ANSI/AFBMA): Load Ratings and Fatigue Life for Ball Bearings.

B. American National Standards Institute/national Electrical Manufacturers Association (ANSI/NEMA): MG 1 - Motors and Generators.

C. American National Standards Institute/National Fire Protection Association (ANSI/NFPA): NFPA 70 - National Electrical Code (NEC).

D. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE)

1. IEEE112 – Standard Test Procedure for Polyphase Induction Motors and Generators

2. IEEE114 – Standard Test Procedure for Single-Phase Induction Motors

E. American National Standards Institute/Underwriters Laboratories, Inc. (ANSI/UL)

1. UL547 – Thermal Protectors for Motors

2. UL674 – Electric Motors and Generators for Use in Hazardous Locations, Class I Groups C and D, Class II Groups E, F and G

F. Institute of Electrical and Electronics Engineers (IEEE)

1. 85 – Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery

2. 43 – Recommended Practice for Testing Insulation Resistance of Rotating Machinery

1.05 SUBMITTALS

A. Submit the following under the provisions of Section 01330 – Submittals:

1. Outline drawings

2. Completed motor data sheets

3. Assembly drawings

4. Anchor bolt location drawings

5. Electrical schematics and wiring diagrams

6. Equipment performance curves and data

7. Bill of installation/assembly materials

8. Equipment weights

9. Catalog data

10. Assembly/disassembly sizes and weights

11. Operating instructions

12. Maintenance and lubrication recommendations

13. Recommended spare parts for startup including prices

14. Special maintenance tool requirements

15. Recommended spare parts list for one year operation

16. Quality control procedures

17. Nondestructive test procedures

18. Acceptance test procedure

19. Surface preparation and painting procedure

20. Shipping, handling, and storage procedures

21. Installation/erection procedure

22. Code compliance certificate

23. Electrical equipment heat run test records

24. Nameplate data

25. Performance/acceptance test report

26. Size of the largest three phase power factor correction capacitor unit which can be connected to three phase motors.

1.06 QUALITY ASSURANCE

A. Tests

1. Inspect and test motors in accordance with specified NEMA standards. Test polyphase motors to the requirements of ANSI/IEEE 112. Test single phase motors to the requirements of ANSI/IEEE 114.

1.07 DELIVERY, STORAGE AND HANDLING

A. Prepare each unit for the type and mode of shipment specified. The preparation shall be suitable for at least six months of outdoor storage from time of shipment requiring no disassembly prior to operation (except for bearing and seal inspections).

B. Provide instructions as necessary to preserve the integrity of the storage preparation after the equipment arrives at the jobsite.

C. Coat exterior machined surfaces with a suitable rust preventative.

D. After drained and cleaned, coat internal areas of bearings and auxiliary equipment in oil lubrication systems fabricated from carbon steel with a suitable oil-soluble rust preventative.

E. Provide threaded openings with steel caps or solid-shank steel plugs. Do not use nonmetallic plugs or caps.

F. When sleeve bearings are furnished, block the rotor to prevent axial and radial movement.

G. When space heaters are furnished, make heater leads accessible without disturbing the shipping package. Tag the leads for identification.

PART 2: PRODUCTS

2.01 MANUFACTURERS

A. General Electric.

B. Reliance Electric.

C. TECO-Westinghouse Motor Company

D. Toshiba.

E. U.S. Motors.

F. Submersible Pump Vendors where motors are integral with the pump.

2.02 DESIGN

A. This specification defines the minimum requirements for low-voltage, random-wound, squirrel-cage, induction motors in the NEMA frame sizes for nonclassified electrical area service. Where this specification is in conflict with Specification 11311, Submersible Wastewater Pumps, Specification 11311 shall govern.

B. Use this specification for the selection and purchase of induction motors purchased separately or furnished with driven equipment as a package.

C. This specification, along with the reference documents make up the requirements for motors up to and including 300 hp. Use driven equipment specifications to supplement this specification and identify special project requirements.

D. Motors purchased with this specification will drive vertical pumps. Motors will be installed in a plant environment that may include high humidity, storms, salt-laden air, insects, plant life, fungus, rodents as well as traces of petroleum and/or chemicals.

E. Motors shall perform satisfactorily for the application and installation conditions.

F. Make motors suitable for operation in an outdoor corrosive and wet environment.

G. When motors are furnished with the driven equipment as a package, motors shall also meet the requirements of the driven equipment specification.

H. Design motors for operation at a temperature of up to 40 degrees C/104 degrees F ambient and at an elevation of up to 1000 m/3300 ft above sea level.

2.03 PERFORMANCE REQUIREMENTS

A. Confirm motors have ample capacity to supply the maximum output demanded by the driven equipment and have a speed-torque-current characteristic appropriate to the driven equipment. Where new motors are provided for existing pumps, match new motor characteristics to pumps.

B. Confirm motors ability to overcome starting load inertia and accelerate the load to rated speed within 15 seconds at 80 percent of rated nameplate voltage, without exceeding the motor time-temperature damage curve.

C. Design and construct motors for continuous full load duty. Motors may also operate intermittently.

D. Three-phase induction motors shall be ANSI/NEMA MG 1 Design B. Motors driving high-torque loads may be NEMA Design C or D, providing so stated in the proposal.

E. Single-phase fractional horsepower motors shall be NEMA Design N.

F. Single speed, polyphase motors shall have efficiencies which equal or exceed those in ANSI/NEMA MG-1 (latest edition) for “NEMA Premium Efficiency” motors. Motor nameplate shall indicate that motor is a “NEMA Premium Efficiency” motor.

2.04 ENCLOSURES AND FRAMES

A. Motors shall be provided with NEMA Type TEFC enclosures, except for submersible pump applications.

B. Motors frames, enclosures, terminal boxes, fan cover guards and air passages shall be cast iron or heavy fabricated steel of such design or proportions as to hold all motor components rigidly in proper position, and shall meet all NEMA requirements for the type of enclosure employed. End bells shall be cast iron. Steel sheet or plate used shall have a thickness of at least 1/8 in. Fans, breathers, drains, screens, covers and hardware shall be corrosion-resistant materials. Fractional horsepower motors may have rolled steel stator frame and cast iron brackets with integral mounting feet.

C. Make motor enclosure fans low inertia, nonsparking type, and suitable for bidirectional rotation and mount on hub with stainless steel bolts.

D. Furnish each enclosure with a stainless steel automatic breather/drain located at the low point of the enclosure.

E. Motor frame and enclosure shall have provisions for grounding to the main grounding system. Drill and tap rear foot on horizontal motors and the flange base on vertical motors on the junction box side for a service post ground connector.

F. Provide motors weighing more than 300 lbs. with lifting eyebolts, rings or lugs capable of supporting the weight of the motor.

2.05 ELECTRICAL REQUIREMENTS

A. Motors shall be rated as follows:

1. 460 volts, three phase, 60 Hz. where the source voltage is 480 volts.

2. 230 volts, three phase, 60 Hz. where the source voltage is 240 volts.

B. Induction motors shall be random-wound, squirrel-cage rated for continuous duty and suitable for across-the-line starting, at rated voltage.

C. Determine motor speed, torque and special operating requirements from the requirements of the driven equipment.

D. Use copper for motor windings and terminal leads. Aluminum is not an allowable material for any portion of the motor other than die-cast rotor (fabricated aluminum rotors are not acceptable). Copper rotors shall not be fabricated using brazing maler and any copper alloy must contain less than two percent phosphorous.

E. Three-phase single speed AC motors shall be provided with three leads.

F. Motors shall have a 1.15 service factor (SF) rating unless specified otherwise.

G. Motor insulation shall be a minimum of Class F epoxy nonhygroscopic material with temperature rise limited to Class B design rise of 90 degrees C by resistance method at 1.15 SF. Inverter Duty Motors shall have the highest voltage rated insulation system available for application on the output of VFD's (Variable Frequency Drives). As a minimum, inverter duty motors shall use Phelps–Dodge type QS magnet wire which is pulse resistant, in combination with the motor manufacturer's insulation system.

H. Motors shall operate successfully under running conditions at rated load with variation in voltage and frequency up to the limits set by ANSI/NEMA MG 1-12.44.

I. Unless specified otherwise, motors shall be suitable for the number of full-voltage starts as required by ANSI/NEMA MG 1-12.50 as a minimum.

J. Locked rotor current shall not exceed 5.5 times full load current.

K. Motors operated on VFDs or ASDs shall be rated as inverter duty.

2.06 TERMINAL BOXES

A. Make motor terminal boxes weatherproof and with threaded conduit entrances with water-resistant seals between boxes and motor frame. Design the line-terminal box to allow box to be rotated in four 90 degree steps for bottom, side or top entry of conduit or cable. The line terminal box shall match the location indicated on project drawings. Locate a separate terminal box for space heaters adjacent to the line terminal box. Provide a separate terminal box for RTD's.

B. Size the line terminal box so that feeder cables can be connected to motor leads for terminals without damage to the cable or the leads. Oversize the terminal box to exceed the minimum volumes shown in the NEC Section 430-12 by 100% and provide adequate space to mount and enclose all devices mounted within.

C. Furnish the line terminal box with suitable compression ring-type, permanently numbered, cable connectors for incoming bolted-cable connections and one clamp-type ground terminal lug of sufficient size to contain a conductor the same size as motor leads.

D. Wire accessory leads to a terminal board in a terminal box or boxes separate from the line leads. Supply separate terminal boxes for the leads for space heaters, and temperature detectors, current transformers, and other similar accessories, when supplied.

2.07 ELECTRICAL ACCESSORIES

A. For motors 25 Hp and larger, provide space heaters for optimum uniform heating of the stator winding and prevent condensation in the motor at ambient temperature when motor is not in operation. Space heaters shall be rated 240 V but shall be connected for

operation at 115V. Space heaters shall have maximum sheath temperature of 150 degrees C and shall be approved for the specified hazardous area classification, if so classified.

B. Provide motors 100 horsepower and larger with a minimum of six, three-wire, 100 ohm, platinum RTDs, two per phase, spaced equally around the circumference of the stator. Provide a drawing which shows the location of RTDs in the motor stator.

C. Provide motors 100 horsepower and larger with three-wire, 100 ohm, platinum RTDs, one per bearing.

2.08 BEARINGS AND LUBRICATION

A. Provide oil-lubricated anti-friction ball or roller bearings for motors 100 Hp and larger. Provide grease lubricated bearings for motors less than 100 Hp.

B. Motors shall have proper bearing insulation to prevent circulation of shaft currents and resulting damage. Provide also insulating means for any oil-supply connections and monitoring equipment to prevent electrical bypassing of the bearing insulation.

C. Unless specified otherwise, oil lubricated bearings shall have an L10 rating life in accordance with ANSI/AFBMA 9, of at least 100,000 hours. Grease lubricated bearings shall have a rating life of at least 40,000 hours.

D. Provide oil-lubricated bearing housings and a reservoir of sufficient depth, to serve as a settling chamber for foreign materials, with a drain plug, and vents as required, accessible from the exterior of the motor. Furnish oil-lubricated motors with a constant oil-level sight gauge mounted on the motor housing and marked with running- and stopped-oil levels.

E. Provide motors with suitable seals to prevent moisture from entering through the shaft openings. Provide an Inpro/Seal isolator (labyrinth seal) on the shaft end of the motor.

F. For in-line pumps, special high thrust bearings are required for drive motors, except for pumps where the thrust bearings are provided as an integral part of the pump.

2.09 ADDITIONAL REQUIREMENTS FOR VERTICAL MOTORS

A. Solid shaft vertical motors are acceptable for all applications except when the connection to the driven equipment consists of sectional driven shaft which may unscrew and lengthen in the event of reversal of direction.

B. Design vertical motor thrust bearings conservatively to carry maximum axial thrusts (up and down) imposed by driven equipment.

C. Vertical motors shall have oil-lubricated, top and bottom bearings.

D. Vertical motor bases (Stands) shall be NEMA Type P.

E. Provide vertical motors with a positive, nonreversing, corrosion-resistant ("anti-ratchet") mechanism.

F. Where new motors are being provided for existing pumps, motor mounting must match the existing pump, and new shaft couplings shall be provided to couple the pump to the new motor.

2.10 SOLE PLATE

A. See pump vendor for requirements.

2.11 ROTOR BALANCING AND VIBRATION

A. Balance motor rotors dynamically according to NEMA standards. Depositing weld metal, solder and the like on the rotor to effect a balance will not be acceptable. Remove parent metal to achieve balance without affecting the structural strength of the rotor. Chiseling or sawing parent metal is prohibited.

B. Measure vibration in all directions with the motor running uncoupled at no load, normal voltage and frequency, and at each speed of the operating range. Motor vibration shall not exceed the total amplitude, peak-to-peak values given in ANSI/NEMA MG 1-Part 7 as measured in accordance with ANSI/NEMA MG 1-Part 7. Perform a second test and measure vibration in all directions with the motor running coupled to the load with normal load, normal voltage, normal frequency, and typical speeds of the operating range. Vibration testing shall be performed by an experienced third party company not associated with the contractor, subcontractors, pump or motor vendors.

C. Where indicated on project drawings, provide a Metrix Instrument Co., PMC/Beta Model 440D vibration switch with manual reset switch, normally open dry output contact for alarm and normally closed dry output contact for shutdown. Provide a pre-drilled mounting location for the vibration switch.

2.12 NAMEPLATES

A. Fasten motor stainless steel nameplates securely to the motor with stainless steel screws. Nameplates shall include as a minimum the information required by ANSI/NEMA MG 1.

2.13 FINISH

A. Motors shall be primed and finished using the motor manufacturer's standard epoxy painting system unless specified otherwise.

B. Cover internal surfaces, e.g., shaft, rotor, stator, and other similar components, with a corrosion-resistant coating of epoxy or equal material for increased life.

2.14 NOISE LEVELS

A. Determine motor noise level in accordance with IEEE 85. Levels or noise generated by a motor shall not exceed 85 dbA at a distance of 1 m/3.3 ft unless specified otherwise on the data sheet.

B. Noise level requirements may be also covered by a separate noise requirements specification included with the driven equipment specification.

PART 3: EXECUTION

3.01 PREPARATION

A. Verify motor and motor base match mounting provisions for the driven equipment.

3.02 SETTINGS

A. Where GE Multilin Motor Protection Relays are provided for motor protection, provide all settings for the Multilin units.

B. Provide all settings for PMC/Beta Vibration Switches.

3.03 INSTALLATION

A. Install each motor in accordance with the Manufacturer's published instructions using the necessary tools and instrument to ensure proper fit and alignment with the driven machine.

B. Enter settings for GE Multilin Relays where Multilin relays are provided for motor protection.

C. Enter settings for PMC/Beta Vibration Switches.

D. Before coupling up with the driven machine, the following work should be performed.

1. Test the motor winding insulation resistance in accordance with IEEE 43.

2. Terminate cables to the motor leads.

3. Energize motor momentarily to check rotation.

4. Check shaft of driven machine to ensure free movement.

5. Perform motor vibration tests.

E. Couple motor up with driven machine.

1. Perform motor vibration tests.

END OF SECTION

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Section 16175

LOW VOLTAGE ADJUSTABLE SPEED DRIVES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. This specification covers a complete adjustable speed motor drive (ASD) consisting of a space vector sine-coded Pulse-Width Modulated (PWM) inverter for use with a standard NEMA Design B induction motor in variable torque applications. An input AC line reactor shall be included. An output line reactor shall be included due to the distance from the ASD to the motor.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be provided for work performed under this Section. Include the cost for this work in the lump sum base bid.

B. Refer to Section 01270 – Measurement and Payment.

1.03 RELATED WORK

A. Section 01270 – Measurement and Payment.

B. Section 01330 – Submittal Procedures.

C. Section 01340 – Shop Drawings, Product Data, and Samples.

D. Section 01782 – Operations and Maintenance Data.

E. Section 16171 – Low Voltage AC Electric Motors.

F. Section 16195 – Electrical identification.

1.04 QUALITY ASSURANCE

A. Referenced Standards.

1. Institute of Electrical and Electronic Engineers (IEEE). Standard 519-1992, IEEE Guide for Harmonic Content and Control.

2. Underwriters Laboratories. UL 508.

3. National Electrical Manufacturer's Association (NEMA). ISC 6, Enclosures for Industrial Controls and Systems.

4. EEC 801-2, 801-4, 255-4.

5. NFPA 70, National Electrical Code.

B. Testing. All printed circuit boards shall be completely tested and burned-in before being assembled into the completed ASD. The ASD shall then be subjected to a preliminary functional test, minimum 8-hour burn-in, and computerized final test. The burn-in shall be at full current or cycled load.

C. Failure Analysis. ASD manufacturer shall have available an analysis laboratory to evaluate the failure of any component.

D. Qualifications. ASDs shall be UL Listed.

1.05 SUBMITTALS

A. Submittals shall be provided in accordance with Specification Section 01330 – Submittal Procedures and shall include the following information:

1. Certificate of Unit Responsibility, attesting that the ASD manufacturer has accepted unit responsibility for the proper functioning of each ASD in conjunction with its respective motor and pump. No other submittal will be reviewed until the certificate has been received and found to be in conformance with this requirement.

2. Outline dimensions.

3. Weight.

4. Typical efficiency vs. speed graph for variable torque load.

5. Compliance to IEEE 519 - Harmonic analysis for particular jobsite including total voltage harmonic distortion and total current distortion.

a. The ASD manufacturer shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 5%. AC Input 5% line reactors shall be sized and provided to ensure compliance with IEEE standard 519-1992, Guide for Harmonic Control and Reactive Compensation for Static Power Converters. The acceptance of this calculation must be completed prior to ASD installation.

b. Prior to installation, the ASD manufacturer shall provide the estimated total harmonic distortion (THD) caused by the ASD's. The results shall be based on a

computer aided circuit simulation of the total actual system, with information obtained from the power provider and the user.

c. If the voltage THD exceeds 5%, the ASD manufacturer is to recommend the additional equipment required to reduce the voltage THD to an acceptable level.

d. ASD's with 18-pulse or greater input shall have transformer-rectifier input sections.

6. Complete electrical power and control diagrams showing the control, and protection systems, illustrating the protection, control, trip and alarm functions at the different locations, reference signals and commands, and the auxiliary supplies (i.e. air, electrical auxiliary supplies, etc.). Wiring diagrams shall be fully explicit 3-line diagrams showing all power and control point-to-point connections.

7. Operations and Maintenance Data in accordance with Specification Section 01782.

1.06 WARRANTY

A. Warranty shall be 12 months from the date of certified start-up. The warranty shall include all parts, labor, travel time, and expenses.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers: Siemens/Robicon W150 Series or approved equal.

B. The ASD manufacturer shall:

1. Have an existing sales representative for water and wastewater plant applications, with expertise in controls.

2. Have an independent local service organization.

3. Provide the drive and all necessary controls, as herein specified. Manufacturer shall have been engaged in the production of this type of equipment for a minimum of 10 years.

4. Design the ASD specifically for variable torque applications.

5. Design the ASD specifically for use with standard NEMA Design B induction motors (not inverter duty motors).

2.02 ADJUSTABLE SPEED DRIVES

A. The adjustable speed drives (ASD's) shall be solid state, with a Pulse-Width Modulated (PWM) output waveform. The drive efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be 95% at all speeds and loads. An input AC line reactor shall be provided. An output line reactor shall be provided due to the distance from the ASD to the motor.

B. All ASDs shall have the following specifications:

1. Input: 460 VAC +/-10%, 3 phase, 48 - 63 Hz.

2. Output: 3 phase, 0 to 120 Hz. Operation above 60 Hz. shall require programming changes to prevent inadvertent high speed operation.

3. Environmental operating conditions: 0 to 400C @ 3 kHz switching frequency, 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.

4. ASDs for application on motors less than 30 HP shall have a six pulse input. ASDs for application on motors 30 HP and larger shall have an 18 or greater pulse input.

5. ASD enclosure shall be rated NEMA Type 1.

C. All ASDs shall have the following standard features:

1. All ASDs shall have the same customer interface, including digital display, keypad and customer connections; regardless of horse power rating. The keypad is to be used for local control, for setting all parameters, and for stepping through the displays and menus.

2. The ASDs shall give the user the option to either display a fault or run at a programmable preset speed.

3. The ASDs shall utilize a plain English digital display (code numbers and letters are not acceptable). The digital display shall be a 40-character (2 line x 20 characters/line) LCD display. The LCD shall be backlit to provide easy viewing in any light condition. The contrast should be adjustable to optimize viewing at any angle. All set-up parameters, indications, faults, warnings and other information must be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.

4. The ASDs shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. The number of restart attempts shall be a minimum of four.

5. The ASDs shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

6. The ASDs shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia. Removing power from the motor is not an acceptable method of increasing power loss ride-through.

7. The customer terminal strip shall be isolated from the line and ground.

8. Prewired 3-position Hand-Off-Auto switch and speed potentiometer. When in "Hand", the ASD will be started, and the speed will be controlled from a local speed potentiometer. When in "Off', the ASD will be stopped. When in "Auto", the ASD will start via an external contact closure, and its speed will be controlled via an external speed reference.

9. The drive shall employ three current limit circuits to provide trip free operation:

    a. The Slow Current Regulation limit circuit shall be adjustable to 115% (minimum) of the ASD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load.

    b. The Current Switch-off limit shall be fixed at 180% (minimum, instantaneous) of the ASD's variable torque current rating.

10. The overload rating of the drive shall be 110% of its variable torque current rating for 1 minute.

11. The ASD shall have an input circuit breaker in the drive enclosure rated at 65 kAIC interrupting capacity. Circuit breaker shall be padlockable in the "Off" position.

12. The ASD shall have a 3% AC line reactor to reduce harmonics to the power line, to increase the fundamental power factor and to eliminate nuisance tripping due to voltage spikes and anomalies.

13. The ASD shall be optimized for a 3 kHz carrier frequency to reduce motor noise and provide high system efficiency. The carrier frequency shall be adjustable by the start-up engineer.

14. The ASD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.

15. The ASD shall not contribute any short-circuit current to an upstream short-circuit fault.

16. The ASD shall be high-efficiency, high power factor, low-harmonic type.

17. The ASD shall have an output line reactor due to the distance from the ASD to the motor.

D. All ASDs shall have the following adjustments:

1. Interposing power blocks ahead of the main circuit breaker input terminals to facilitate connection of the power feeders sized as shown on the drawings.

2. Three (3) programmable critical frequency lockout ranges to prevent the ASD from continuously operating at an unstable speed.

3. PI setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the ASD, using the microprocessor in the ASD for the closed loop control; thus eliminating the need for external controllers.

4. Two (2) analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual (feedback) signals for PI controller. Analog inputs shall include a filter; programmable, from 0.01 to 10 seconds to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0 - 20 mA and 0 - 10 Volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz.

5. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices.

6. One analog output proportional to Frequency.

7. Outputs must be true form C type contacts; open collector outputs are not acceptable.

8. Seven (7) programmable preset speeds.

9. Two independently adjustable acceleration and deceleration ramps. These ramp times shall be adjustable from 0.3 to 1200 seconds.

10. The ASD shall Ramp or Coast to a stop, as selected by the user.

E. The following operating information displays shall be standard on the ASD digital display. The display shall be in complete English words (alpha-numeric codes are not acceptable):

1. Output Frequency
2. Motor Speed (RPM, % or Engineering units)
3. Output Current
4. Output Voltage
5. Heatsink Over-temperature
6. Analog Input Values
7. Keypad Reference Values
8. Elapsed Time Meter
9. kWh meter

F. The ASD shall have the following protection circuits. In the case of a protective trip, the drive shall stop, and announce the fault condition in complete words (alphanumeric codes are not acceptable).

1. Overcurrent trip.
2. Overvoltage trip.
3. Undervoltage trip.
4. Over-temperature.
5. Ground Fault either running or at start.
6. Adaptable Electronic Motor Overload (I2t). The Electronic Motor Overload protection shall protect the motor based on speed and the pump load curve. Circuits which are not speed dependent are unacceptable. The electronic motor overload protection shall be UL Listed for this function.

G. Speed Command Input shall be via:

1. Keypad.
2. Two Analog inputs, each capable of accepting a 0-20mA, 4-20mA, 0-10V, 2-10V signal. Input shall be isolated from ground. The analog input should be able to be inverted, so that minimum reference corresponds to maximum speed, and maximum

reference corresponds to minimum speed. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0 - 20 mA and 0 - 10 Volts.

H. Serial Communications.

1. The ASD shall have RS-232 and RS-485 ports as standard.

2. The ASD shall be able to communicate with programmable logic controllers (PLC's), distributed control systems (DCS's), and direct digital controls (DDC's).

3. Serial communication capabilities shall include, but not be limited to, run-stop control, speed set adjustment, proportional/integral PI controller adjustments, current limit, and accel/decel time adjustments. The drive shall have the capability of allowing the DDC to monitor feedback such as output speed/frequency, current (in amps), % torque, % power, kilowatt hours, relay outputs, and diagnostic fault information.

4. The ASD shall provide Modbus communication protocol, either built-in or on an integrated communications board.

I. Accessories to be furnished and mounted by the drive manufacturer.

1. Customer Interlock Terminal Strip - provide a separate terminal strip for connection of external start/stop command. All external interlocks and start/stop contacts shall remain fully functional whether the drive is in Hand or Auto.

2. All wires to be individually numbered at both ends for ease of troubleshooting.

3. Door interlocked disconnect switch which will disconnect all input power from the drive and all internally mounted options. The disconnect handle shall be through-the-door type, and be padlockable in the "Off" position.

4. The ASD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.

PART 3: EXECUTION

3.01 INSTALLATION

A. Power and control wiring shall be completed by the Contractor. The Contractor shall complete all wiring in accordance with the recommendations of the ASD manufacturer as outlined in the installation manual.

3.02 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the Owner, and a copy kept on file at the manufacturer.

END OF SECTION

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Section 16195

ELECTRICAL IDENTIFICATION

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specification for electrical identification including:

1. Nameplates and labels
2. Wire and cable markers
3. Conduit markers
4. Cable tray markers
5. Underground warning tape
6. Warning labels

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work performed under this Section. Include the cost for this work in the lump sum Base Bid.

1.03 REFERENCES

A. American National Standards Institute/National Fire Protection Association (ANSI/NFPA)

1. No. 70 - National Electrical Code (NEC)

a. Article 110 - Requirements for Electrical Installation

b. Article 430 - Transformers and Transformer Vaults

B. City of Houston Building Code

C. Other applicable Codes and Standards as referenced in other Sections.

D. Underwriters Laboratories. U.L. Standards No. 224 - Extruded Insulated Tubing

1.04 SUBMITTALS

A. Submit the following under the provisions of Section 01330 Submittal Procedure:

1. Manufacturer's cut sheets and catalog data
2. Description of materials used
3. Label or nameplate dimensions
4. Engraving or imprint legends
5. Instruction for handling and storage
6. Installation instructions

1.05 DELIVERY, STORAGE AND HANDLING

A. Pack materials to permit ease of handling and to provide protection from damage during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Almetek Industries Incorporated

B. Brady U.S.A. Incorporated

C. Ideal Electric Company

D. Raychem Corporatio

E. 3M Electrical Products Division

F. Thomas & Bett

G. Tyton Corporation

2.02 MATERIALS AND EQUIPMENT

A. Nameplates and Labels

1. Provide an identification tag for each item of electrical and instrumentation equipment showing its item number and service or application. Use the description shown on the electrical Drawings.

2. For nameplates, use 3-ply phenolic material engraved to show black lettering on a white background. Size the nameplates approximately 1 inch wide and 3 inches long for 3 lines of 3/16 inch - 16 letters with a 0.8 condensed factor.

3. Generally, provide large pieces of equipment with engraved nameplates; provide additional nameplates at pushbuttons and other local devices; as detailed. Provide identification for all other electrical and instrumentation equipment, devices, or enclosures, such as MCC's, panelboards, disconnect switches, capacitors, relays, and dedicated receptacles not furnished with readily noticeable tag, nameplates, or other means of identification.

4. Install nameplates on the front cover of transformers stating the transformer service location number or identification number, the panelboard or device served, and main breaker feeding the transformer (MCC No. and compartment), and the drawing number on which the transformer schematic is shown.

5. Furnish equipment, such as motor starters, safety switches, welding receptacles and circuit breakers, with 1" x 3" plastic nameplates stating description of item served.

6. Provide nameplates for motors giving the driven equipment description, the service location number, and the MCC number with compartment number when applicable. Nameplates will normally be mounted adjacent to the motor at the motor pushbutton when one is furnished.

7. Install nameplates on the outside and inside of doors to circuit breaker panelboards (i.e., lighting, instrument or receptacle panels). State the panelboard name, the drawing number on which the panelboard schedule shows, and the main breaker feeding the panel (MCC No. and compartment).

8. Type panelboard directories and insert them inside the panelboard doors.

9. Place a large nameplate no less than 3"x5" on control panels, relay panels, junction boxes, or enclosures with electrical devices mounted inside or on the outside of the enclosure indicating the purpose of the cabinet.

10. Provide a nameplate on MCC motor starter doors duplicating motor nameplate data.

B. Wire and Cable Markers

1. Use pre-printed tubular heat-shrink type wire and cable markers at each end of all conductors.

2. Select markers manufactured so that the heat-shrink process makes the imprint permanent and solvent-resistant.

3. Use markers that are self-extinguishing, conforming to U.L. Standard No. 224 for print performance, heat shock, and flammability.

4. Provide marker material that is flexible, radiation cross-linked polyolefin with 3 to 1 shrink ratio, rated 600 volts, and white in color.

C. Conduit Markers

1. Provide conduit markers made of stainless steel tags approximately 2 inches x 1 inch x 19 gage.

2. Stamp the caption on the tag and have it black filled.

3. Punch tags for tie fasteners. Fasten tags to the conduits with stainless steel braided wire.

D. Cable Tray Markers

1. For high visibility and contrast, use cable tray markers that are yellow with black legend.

2. Use markers made of vinyl impregnated cloth, suitable for exposure to corrosive, wet, and abrasive environment.

3. Make markers of pre-cut individual letters or numbers with pressure sensitive adhesive backing.

4. Size legend characters to 4 inches high on a total marker height of approximately 5 inches, suitable for applying to 6-inch side rails of a cable tray.

E. Underground Warning Tape

1. Provide warning tape made of 4 mil thick polyolefin film, 3 inches wide, suitable for direct burial and resistant to alkalis, acids, and other common soil substances.

2. Use red tape with black legend printed in permanent ink.

F. Warning Labels

1. Place OSHA safety labels on enclosures and boxes 100 cubic inches or more containing electrical equipment or terminations.

2. Provide OSHA color codes for the labels. Use labels made from 4 mil vinyl with pressure sensitive adhesive backing.

3. The warning label caption is DANGER - 480 VOLTS or as indicated on the drawings

4. Size labels either 5 inches x 3-1/2 inches or 10 inches x 7 inches, as indicated on the Drawings.

PART 3: EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces where adhesive labels will be applied.

B. Drill holes for nameplates to be fastened with stainless screws.

C. Prepare the cable ends for termination and conductor markings.

D. Identify conduits at terminating points and select tags accordingly.

3.02 INSTALLATION

A. Install nameplates and labels in accordance with the manufacturer's instructions and the Drawings.

B. Apply wire and cable markers in accordance with manufacturer's instructions using a heat gun with properly sized nozzle for the application. Tag the wires at both ends with the same notation.

C. Tag conduits at junction boxes, pull boxes, and at other termination points.

D. Identify cable trays at the time of installation with the alphanumeric number shown on the Drawings. Label cable trays on the outside rail. Place the tray identifier at each point where the tray designation changes and at 200 foot intervals in between, but not less than two per run.

E. Identify underground conduits, cables, or duct banks using the underground warning tape. The underground grounding grid, including the laterals. Also use underground warning

tape. Install one tape per trench at 12 inches below grade or as indicated on the Drawings. For wide trenches or duct banks, install one warning tape per 24 inch width.

F. Apply the 5 inches by 3 1/2 inches warning labels to disconnect switches, panelboards, terminal boxes, and similar devices in accordance with manufacturer's instruction and the Drawings. Apply the 10 inches x 7 inches warning labels to larger control panel enclosures, motor control centers, and to entrance doors to buildings containing electrical power and control equipment.

END OF SECTION

Section 16402

UNDERGROUND DUCT BANKS

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Underground electrical duct banks.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. National Fire Protection Association (NFPA): No. 70 - National Electrical Code (NEC) Appendix B.

1.04 SUBMITTALS

A. Catalog cut sheets of the ducts and spacers.

1.05 DELIVERY, STORAGE AND HANDLING

A. Have duct spacers and associated hardware packed and crated to avoid damage during shipment and handling.

B. Clearly mark packages or crates stating that the material is for electrical duct banks only.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Thomas and Betts.

B. Underground Devices Inc.

C. Walker Division, Butler Manufacturing Company.

2.02 MATERIALS AND EQUIPMENT

A. Conduit. Construct ducts using Schedule 40 Rigid PVC conduit. Refer to Section 16111 - Conduit, Fittings and Bodies.

B. Spacers. Secure conduit with non-magnetic, universal, interlocking-type spacers for both horizontal and vertical duct arrangements.

C. Concrete. Use steel reinforced, red concrete as duct encasement. Refer to Section 03100 Concrete Formwork.

PART 3: EXECUTION

3.01 PREPARATION

A. Verify from Drawings and field survey that the location of ductbanks does not interfere with any existing or new underground facilities.

B. Verify that materials are on site in proper condition and that sufficient quantity is on hand for the work.

C. Verify that trenches are in the correct places and prepared with sufficient depth and width to accommodate the duct banks, reinforcing rod, and concrete.

D. Be prepared for inspection of the duct banks before reinforcing rod is installed.

E. Before pouring concrete, verify that the ducts are free of debris and properly installed in the support and spacer systems and that the ducts are properly fitted together and firmly held in place by the hold down hardware.

F. Provide 24-hour notice to Project Manager, Wastewater Inspectors and the Local Code Inspector for cover-up inspection before pouring electrical conduit ductbanks.

3.02 INSTALLATION

A. Use the size and types of conduit as indicated on the Drawings for the various duct banks required for the project.

B. Make duct bank installations and penetrations through foundation walls watertight.

C. Assemble duct banks using non-magnetic saddles, spacers and separators. Position separators to provide 2-inch minimum concrete separation between the outer surfaces of the conduits.

D. Provide a 3-inch minimum concrete covering on both sides, top and bottom of concrete envelopes around conduits. Add red dye at the rate of 10 pounds per cubic yard to concrete used for envelopes for easy identification during subsequent excavation.

E. Firmly fix ducts in place during pouring of concrete. Carefully spade and vibrate the concrete to ensure filling of spaces between ducts.

F. Make bends with sweeps of radius not less than 6 times the smallest diameter of the raceway.

G. Make a transition from non-metallic to pvc-coated metallic rigid conduit where duct banks enter structures or turn upward for continuation above grade.

H. Make bends of 30 degrees or more using PVC-coated rigid galvanized steel elbows.

I. Reinforce duct banks throughout, where indicated on the Drawings.

   1. Unless otherwise noted on the Drawings, reinforce with No. 5 longitudinal steel bars placed at each corner and along each face at a maximum parallel spacing of 12 inches on centers, and No. 5 tie-bars transversely placed at 18-inch maximum longitudinal intervals.

   2. Maintain a maximum clearance of 2 inches from bars to the edge of the concrete encasement.

J. Where ducts enter structures such as handholes, manholes, pullboxes, or buildings, terminate the ducts in suitable end bells, insulated L-bushings, Meyers hubs or couplings on steel conduits. Tag conduit entering pull boxes with stamped, stainless steel tags. Identify as designated in cable and conduit schedule.

K. Do not backfill with material containing large rock, paving materials, cinders, large or sharply angular substances, corrosive material, or other materials which can damage or contribute to corrosion of ducts or prevent adequate compaction of fill.

L. Install a bare stranded copper duct bank ground in each duct bank envelope. Make ground electrically continuous throughout the entire duct bank system. Connect ground to switchgear and MCC ground buses and to steel conduit extensions of the underground duct system.

M. After completion of the duct bank and prior to pulling cable, pull a mandrel, not less than 12 inches long and with a cross section approximately one-fourth inch less than the inside cross section of the duct, through each duct. Then pull a rag swab or sponge through to remove any particles of earth, sand or gravel that may have been left in the duct. Repull the rag or sponge swab until the swab emerges clean.

N. Use hemp rope to pull conductors into PVC conduit. Do not use nylon or wire cable for this purpose.

O. Install a warning ribbon approximately 12 inches below finished grade over underground duct banks. Refer to Section 16195 - Electrical Identification.

P. For manholes and pull boxes below grade, install wire racks to support cables properly around the perimeter and keep them dry.

Q. For manholes and pull boxes below grade, construct a french drain, or other drainage as detailed on the Drawings.

END OF SECTION

SECTION 16426F

METAL-ENCLOSED LOW VOLTAGE FRONT ACCESSIBLE DRAWOUT SWITCHGEAR

PART 1 GENERAL

1.01 SCOPE

A. The Contractor shall furnish and install, where indicated on the drawings, a deadfront type, front accessible low voltage metal-enclosed switchgear assembly drawout power circuit breakers, as specified herein and as shown on the contract drawings.

B. The equipment shall not require rear access for any cable terminations, control wiring or bus inspection. The equipment shall be certified to be installed against a wall without compromise to system integrity or performance.

1.02 RELATED SECTIONS

A. Section 01110 – Summary of Work

B. Section 01330 – Submittal Procedures

C. Section 01782 – Operational and Maintenance Data

D. Section 16195 – Electrical Identification

1.03 REFERENCES

A. The low voltage metal-enclosed switchgear assembly and all components shall be designed, manufactured, and tested in accordance with the following latest applicable standards:

1. ANSI-C37.20 – Switchgear assemblies
2. ANSI-C37.13 – Low voltage power circuit breakers
3. ANSI-C37.17 – Trip devices
4. NEMA SG-5 – Switchgear assemblies
5. NEMA SG-3 – Low voltage power circuit breakers
6. UL 1558.

1.04 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Master drawing index
2. Front view and plan view of the assembly
3. Floor Plan
4. Top View
5. One-line diagram
6. Schematic diagram
7. Nameplate schedule

8. Component list
9. Conduit space locations within the assembly
10. Assembly ratings including:
    a. Short-circuit rating
    b. Voltage
    c. Continuous current rating
11. Major component ratings including:
    a. Voltage
    b. Continuous current rating
    c. Interrupting ratings
12. Cable terminal sizes
13. Product data sheets.

1.05 SUBMITTALS – FOR RECORD PURPOSES

A. The following information shall be submitted for record purposes:
   1. Final as-built drawings and information for items listed in paragraph 1.04
   2. Wiring diagrams
   3. Certified production test reports
   4. Installation information
   5. Seismic certification.

B. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

1.06 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The maximum equipment footprint is shown on the drawings. The manufacturer will provide a statement of conformance to the contractor at time of bid submittal response spectra.

1.07 REGULATORY REQUIREMENTS

A. The switchgear shall bear a UL 1558 label.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.09 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton

B. Schneider Electric (Square D Company)

C. General Electric

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 RATINGS

A. Voltage rating shall be as indicated on the drawings. The entire assembly shall be suitable for 600 volts maximum AC service.

B. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current of 85,000.

C. The bus system shall have a minimum ANSI 4-cycle short-circuit withstand rating of 100,000 amperes symmetrical.

D. All circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes. To ensure a fully selective system, all circuit breakers shall have 30 cycle short-time withstand ratings equal to their symmetrical interrupting ratings, regardless of whether equipped with instantaneous trip protection or not.

E. All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50 and C37.51 and UL witnessed and approved.

2.03 CONSTRUCTION

A. The switchgear shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure.

B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills providing the floor is level to 1/8 inch per 3-foot distance in any direction. Provisions shall be made for jacking of shipping groups, for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids.

C. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments and a centralized bus compartment. A front cable access compartment shall be provided as part of, or beside each breaker structure. Each individual circuit breaker compartment shall be segregated from adjacent compartments and sections by means of steel barriers to the maximum extent possible. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Removable hinge pins shall be provided on the breaker compartment door hinges. Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells and be front accessible and removable.

D. The circuit breaker door design shall be such that the following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.

E. The removable power circuit breaker element shall be equipped with disconnecting contacts and interlocks for drawout application. It shall have four positions, “connected,” “test,” “disconnected” and “removed.” The breaker drawout element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Levering shall be accomplished via the use of conventional tools. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering “in” or “out” of the cell. The breaker shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall provide for securing the breaker in the connected, test, or disconnected position by preventing levering.

F. No rear access shall be required for power cable terminations, connections or inspection. Only front access shall be available for equipment installation, and the switchgear shall be installed against a back wall. Switchgear which does not meet this requirement will not be considered for this project.

G. The switchgear shall be suitable for use as service entrance equipment when required and be labeled in accordance with UL requirements.

2.04 BUS

A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).

B. The vertical bus in each section shall be arranged so that the circuit breaker modules shall be easily and quickly inserted or withdrawn. The vertical bus bars in each section shall be copper. The vertical bus in each distribution section shall be extended to the maximum height available in the section. This shall allow for the future addition of feeder breakers without modification of the vertical bus.

C. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.

D. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly.

E. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers.

2.05 WIRING/TERMINATIONS

A. Small wiring, necessary fuse blocks and terminal blocks within the switchgear shall be furnished as required. Control components mounted within the assembly shall be suitably marked for identification corresponding to the appropriate designations on manufacturer's wiring diagrams.

B. Provide a front accessible, isolated vertical wireway for routing of factory and field wiring. Factory provisions shall be made for securing field wiring without the need for adhesive wire anchors.

C. Front access to all circuit breaker secondary connection points shall be provided for ease of troubleshooting and connection to external field connections without the need of removing the circuit breaker for access.

D. All control wire shall be type SIS. Wire bundles shall be secured with nylon ties and anchored to the assembly with the use of pre-punched wire lances or nylon non-adhesive anchors. All current transformer secondary leads shall first be connected to conveniently accessible shorting terminal blocks before connecting to any other device. Shorting screws with provisions for storage shall be provided. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips and provisions for #10 AWG field connections.

E. NEMA 2-hole mechanical-type lugs shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size indicated on the drawings.

F. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.

2.06 CIRCUIT BREAKERS

A. All protective devices shall be low voltage power circuit breakers. EATON (Cutler-Hammer type) Magnum DS or approved equal. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

B. Breakers shall be provided in drawout configuration.

C. Power circuit breakers shall utilize a two-step stored-energy mechanism to charge the closing springs. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation.

D. Breakers shall be manually operated (MO) is indicated on the drawings.

E. Electrically operated breakers shall be complete with 120V AC motor operators. The charging time of the motor shall not exceed 6 seconds.

F. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.

2.07 SURGE PROTECTION DEVICE

A. Provide a surge protection device (SPD) unit for the main circuit breaker rated 250 kA per

phase and 125 kA per mode. SPD to conform to ANSI/UL 1449 (4TH Edition). SPD to include integral monitoring status indicators, surge event counter, thermal protection, audio alarm with non power failure contact monitor closure with all related appurtenances

2.08 TRIP UNITS

A. Each low voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. EATON Digitrip 1150+ or approved equal.

B. The trip unit shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip.

C. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.

D. Trip unit shall have selectable thermal memory for enhanced circuit protection.

E. All circuit breakers shall have adjustments for long delay pickup and time, individual adjustments for short delay pickup and time, adjustable instantaneous pickup, and individually adjustable ground fault current pickup and time.

F. The trip unit shall have a 4-character LCD display showing phase, neutral, and ground current. The accuracy of these readings shall be +/- 2% of full scale.

2.09 ENCLOSURES

NEMA 1 Enclosure, fully front accessible.

2.10 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all circuit breakers as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16-inch high, minimum. See specifications 16195 Electrical Identification for additional requirements.

B. Furnish master nameplate giving switchgear designation, voltage ampere rating, short-circuit rating, and manufacturer’s name, date of manufacture location of manufacture, shop order number .

2.11 FINISH

A. All exterior and interior steel surfaces of the switchgear shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchgear shall be ANSI 61.

2.12 ACCESSORIES

A. Provide a floor running portable circuit breaker transfer truck with manual lifting mechanism.

PART 3 EXECUTION

3.01 FACTORY TESTING

A. The switchgear shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchgear shall be tested to ensure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.

B. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute, or 1800 volts for one second, between live parts and ground, in accordance with ANSI C37.20.1.

C. A certified test report of all standard production tests shall be shipped with each assembly.

3.02 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor start-up of the equipment specified under this section for a period of ·10 working days. The Contractor shall provide three (3) copies of the manufacturer's field start-up report.

3.03 TRAINING

A. The Contractor shall provide a training session for up to ten (10) owner's representatives for 4 normal workdays at a jobsite location determined by the owner.

B. The training session shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers, and major components within the assembly.

3.04 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and the contract drawings.

B. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

C. The equipment shall be installed and checked in accordance with the manufacturer's recommendations. This shall include but not limited to:

1. Checking to ensure that the pad location is level to within 0.125 inches per three foot of distance in any direction.
2. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations.
3. Assembling all shipping sections, removing all shipping braces and connecting all shipping split mechanical and electrical connections.
4. Securing assemblies to foundation or floor channels.
5. Measuring and recording Megger readings phase-to-phase, phase-to-ground, and neutral-to-ground.
6. Inspecting and installing all circuit breakers in their proper compartments.

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Section 16461

DRY-TYPE TRANSFORMERS

PART 1: GENERAL

1.01 SECTION INCLUDES

A. Specifications for general purpose dry-type transformers:

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work performed under this Section. Include the cost for this work in the lump sum Base Bid.

1.03 REFERENCES

A. American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA)

1. ANSI No. C89.2: Transformers

2. NEMA TP-1: Guide for determining energy efficiency for distribution transformers

B. Underwriters Laboratories (UL): UL 506 - Standard for Safety Specialty Transformers.

C. American National Standards Institute/National Fire Protection Association ANSI/NFPA): NFPA No. 70 -National Electrical Code (NEC); Article 450 - Transformers and Transformer Vaults.

1.04 SUBMITTALS

A. Submit the following under provisions of Section 01330 – Submittal Procedures:

1. Outline dimensions, support points and unit weight.

2. Electrical characteristics, including impedance and tap configuration.

3. Insulation type, rated temperature rise, and total insulation system.

4. Test reports, for transformers 300 KVA and above, indicating losses at 25, 50, 75 and 100 percent rated load and sound levels.

5. Connection diagrams.

6. Catalog data.

7. Operation and maintenance data.

1.05 QUALITY ASSURANCE

A. Tests. Run manufacturer's test on transformers in accordance with Underwriters Laboratories (U.L.) Standard No. UL-506.

1.06 DELIVERY, STORAGE AND HANDLING

A. Have transformers individually packed and crated to permit ease of handling and to provide protection from damage during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. ACME Transformer

B. Eaton

C. General Electric

D. Hevi-Duty

E. Square D Company

2.02 MATERIALS AND EQUIPMENT

A. Use dry-type transformers for general purpose applications.

B. Provide transformers with copper windings.

C. Select transformers designed and constructed in accordance with NEMA ST-1, NEMA ST-20 and the NEC Article 450.

D. For applications less than 15 kVA, use transformers that are encapsulated, non-ventilated type with 80 degree C temperature rise and 185 degree C insulation class.

E. Provide transformers with full capacity winding taps a minimum of two 2-1/2 percent above and two 2-1/2 percent below normal voltage.

F. For applications 15 kVA and above use transformers that are the drip proof ventilated type for indoor mounting with 80 degree C temperature use and 220 degree C insulation class..

G. Use transformers with sound levels in accordance with NEMA ST-20.

H. Basic impulse level (BIL) shall be 10KV for transformers less than 300 KVA, 30KV for transformers 300KVA and larger.

I. Ground core and coil assembly to enclosure by means of a visible flexible copper strap.

J. Provide transformers with lifting eye bolts or brackets.

K. Provide transformer nameplates of stainless steel, marked in accordance with NEC Article 450-11. Fasten nameplate to the transformers with stainless steel screws or rivets.

L. Refer to the one-line diagram or the Drawings for transformer size, volt and wire configuration.

PART 3: EXECUTION

3.01 PREPARATION

A. Verify dimensions of housekeeping pads or other support structures to ensure proper fit.

B. Verify raceway and wiring drawings that are prepared for the transformers and check them against the manufacturer's information.

C. Verify that the protective devices planned for the transformers are in accordance with NEC Article 450.

3.02 INSTALLATION

A. Install transformers plumb and level and in accordance with manufacturer's instructions and the NEC Article 450.

B. Use flexible conduit for connection to transformer case. Make conduit connections to side panel of enclosure.

C. Mount transformers on isolation pads as required to isolate transformer noise from the buildings structure.

D. Wire transformer primary and secondary in accordance with the nameplate instructions and the designated voltages as shown on the one-line diagram.

END OF SECTION

Section 16670

LIGHTNING PROTECTION SYSTEM

PART 1: GENERAL

1.01 SECTION INCLUDES

A. A lightning protection system, including design, installation and materials is required for all new buildings. The lightning protection vendor shall coordinate with the roofing system vendor during the bid period and during construction.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment will be made for work performed under this Section. Include the cost for this work in the lump sum Base Bid.

1.03 RELATED SECTION

A. Section 16170, Grounding and Bonding.

1.04 REFERENCES

A. American National Standards Institute/National Fire Protection Association (ANSI/NFPA)

1. NFPA No: 780 – Standard for the Installation of Lightning Protection Systems

2. NFPA No: 70 - National Electrical Code

a. Section 250-106 – Lightning Protection Systems

B. American National Standards Institute/Underwriters Laboratories (ANSI/UL)

1. UL 96 - Lightning Protection Components

2. UL 96A - Safety Installation Requirements for Lightning Protection System

3. Lightning Protection Institute (LPI) - LPI 175 - Installation Standards

1.05 SUBMITTALS

A. Submittals the following Section 01330 - Submittal Procedures.

1. Outline dimensions and weights
2. Installation and maintenance manual
3. Catalog data
4. Complete design and construction drawings in the latest version of AutoCAD
5. Underwriters Laboratories, Inc. Master “C” Label certification and a copy of the Master “C” Label plaque.
6. Lightning Protection Institute Certified System certification.

1.06 QUALITY ASSURANCE

A. See Part 3.02 – INSTALLATION

1.07 PREPARATION FOR SHIPPING

A. Pack and crate materials to permit ease of handling and provide protection from damage during shipping, handling and storage.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Advanced Lightning Technology

B. East Coast Lightning Equipment

C. Harger Lightning Protection

D. Thompson Lightning Protection

2.02 DESIGN, CONSTRUCTION AND MATERIALS

A. System Design: Provide a functional and unobtrusive lightning protection system. Departures from the Drawings or submittals shall be submitted to the Project Manager for approval.

B. Lightning Protection Equipment: Materials shall be copper and bronze and of the size, weight, and construction to suit the application and used in accordance with LPI, UL, and NFPA code requirements. Use bolt type connectors and splicers for Class I and Class II structures. Pressure squeeze clamps are not acceptable. Use stainless steel mounting hardware to prevent corrosion. Air terminals shall have bullet point tips for personnel safety. Provide copper down lead conductors. Building steel shall not be used as a substitute for copper down lead conductors.

C. Aluminum Components: Aluminum materials may not be used except on roofs that utilize aluminum roofing components. On aluminum roofs or where aluminum parapet caps are used, utilize aluminum components for roof lightning protection equipment to ensure compatibility. However, use copper down lead conductors and grounding with the bimetal transition occurring at the through roof assembly with an approved bimetal through roof assembly.

D. Use equipment which is UL listed and properly UL labeled. Equipment shall be new, and of a design and construction to suit the application in accordance with accepted industry standards and LPI, UL, NFPA, and NEC code requirements.

PART 3: EXECUTION

3.01 PREPARATION

A. The Contractor is responsible for all coordination between the project subcontractors, including, but not limited to, the following:

1. The lightning protection installer shall install a correct, neat and unobtrusive installation in cooperation with other trades.

2. The roofing contractor shall seal and provide flashing for roof lightning penetrations conforming to the roof manufacturer's recommendations. However, the lightning protection contractor shall designate locations of through roof fittings and submit details of through roof penetrations, as required.

3. Should the roofing manufacturer require any special items such as walk pads or pavers under the components of the lightning protection system, the lightning protection installer shall provide such items. Any necessary roofing materials (patches, adhesive, etc) which are required by the lightning protection system installer, shall be supplied by the roofing manufacturer at no additional cost to the lightning protection system installer.

4. The roofing contractor shall instruct the lightning protection installer of the proper installation procedures for patches, adhesive, etc., if required.

3.02 INSTALLATION

A. Have the system installed by an experienced installation company that is UL listed, a member of the Lightning Protection Institute and an employer of Certified Master Installers of lightning protection systems.

B. A Certified Master Installer shall directly supervise the work. Provide and install a complete conductor network at the roof and include air terminals, connectors, splicers, bonds, copper down leads, and proper ground terminals.

C. Use copper down lead conductors even when aluminum is required on the roof. Do not bring down lead conductors in conduit directly through the roof. Use through roof assemblies with solid brass or stainless steel rods for this purpose. Structural steel may not be utilized for down lead conductors.

D. Upon completion of the installation, the lightning protection installer shall secure and deliver to the Contractor for submittal to the Project Manager, the Underwriters Laboratories, Inc., Master "C" Label certification and plaque and the Lightning Protection Institute Certified System certification. The system will not be accepted without the UL Master "C" Label certificate and plaque and the LPI Certified System certificate.

END OF SECTION

Section 16950

UNINTERRUPTIBLE POWER SUPPLIES

PART 1: GENERAL

1.01 SECTION INCLUDES

A. This section covers Uninterruptible Power Supplies to ensure reliable control system power.

1.02 MEASUREMENT AND PAYMENT

A. No separate payment for bonded plastic lining for concrete structures will be made under this section. Include the cost for this work in the lump sum base bid.

1.03 REFERENCES

A. Each variable frequency drive shall be designed, constructed, and tested in accordance with applicable standards and shall be designed for installation in accordance with the NEC. The UPS shall be UL listed.

1.04 SUBMITTALS

A. Submit product data and shop drawings under provisions of Section 01330 - Submittal Procedures.

1. Submit in complete packages grouped to permit review of related items as outlined in these specifications.

2. Bind submittals in three-ring binders with complete indexing and tab dividers. Completely tag and label equipment information to correspond with Drawings.

3. Review of Submittals will be for conformance to Contract Documents and for application to specified functions.

B. Product Data: Submit descriptive product literature including manufacturer's specifications for each component specified.

C. Drawings

1. Name of manufacturer.

2. Types and model numbers.

3. Rated UPS load capacity and run-time.

4. Overall dimensions and weights.

5. Schematics, including maintenance bypass.

6. Wiring diagrams, including all internal and external devices and terminal blocks.

7. List of diagnostic indicators.

D. Quality Control Submittals

1. Field Reports: UPSes commissioned in the field by the contractor or manufacturer are to include start-up report. The report will include installation overview, any parameter changes to default settings, and confirmation of fail-over test.

E. Operations and Maintenance (O&M) Data.

1. Submit operation and maintenance data notebook in accordance with Section 01782 - Operations and Maintenance Data.

2. Information and drawings submitted must reflect the final installed condition. Revise documents requiring updates following testing and start-up.

3. In addition to the content specified in Section 01782 - Operation and Maintenance Data, provide the following information:

   a. Name, address and telephone number of the UPS supplier's local service representative.

   b. Complete list of supplied system hardware parts with full model numbers referred to system part designations, including spare parts and test equipment provided.

   c. Copy of approved submittal information and system shop drawings as specified in Paragraph 1.3, Submittals, with corrections made to reflect actual system as tested, delivered and installed at the site. Provide half-size blackline reproductions of all shop drawings larger than 11 inches x 17 inches.

   d. Configuration and monitoring software.

   e. Complete up-to-date system software documentation.

   f. Manufacturer's hardware, software, installation, assembly and operations manuals for the UPS. Provide all manuals in PDF format on CD-RW or DVD-RW.

F. Project Record Documents

1. Submit record documents under provisions of Section 01785 - Project Record Documents.

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer shall be a company specializing in manufacturing products specified in this Section, having proven compatibility with the City's existing facilities and at least 3 years of documented experience. The company shall maintain service facilities within 100 miles of the City of Houston.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site in factory-sealed containers. Store and protect products under provisions of Section 01610 - Basic Product Requirements.

B. Check for damage upon receiving products on site.

C. Store products in a clean, dry area; maintain temperature in accordance with NEMA ICS 1.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Maintain area free of dirt and dust during and after installation of products.

B. Provide temporary heating and air conditioning units and equipment required to maintain environmental conditions specified for UPS units..

PART 2: PRODUCTS

2.01 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Manufacturer and Model: Powerware 9130 Tower Model with BD Relay Interface Card and HS-MBP Maintenance Bypass, or equal approved by end user.

B. Rating: Provide uninterrupted conditioned power to PLC and critical components for 10 minutes at a load of 1000 VA.

C. Description: Continuous-duty, online, solid state uninterruptible power system incorporating double-conversion technology. The UPS shall operate in conjunction with the existing electrical system to protect electronic equipment from power disturbances

that may occur in utility power such as voltage fluctuations, brownouts, blackouts, power surges and power sags.

D. Modes of Operation: The UPS shall operate as an online, double-conversion UPS with the following modes:

1. Normal Mode: The rectifier shall derive power as needed from the commercial AC utility or generator source and supply filtered and regulated DC power to the online inverter. The inverter shall convert the DC power at its input to highly regulated and filtered AC power for the critical loads.

2. High Efficiency Mode: In the presence of favorable incoming utility conditions, the UPS shall optimize its operating state to maximize its efficiency.

3. Battery Mode: Upon complete failure of utility power, the UPS shall provide power to the critical loads through the inverter, from the UPS' internal or extended batteries. When utility power returns, the unit shall return to Normal Mode operation.

4. Bypass Mode: The automatic bypass shall transfer the critical load to the commercial AC source, bypassing the UPS' inverter/rectifier, in the case of an overload, load fault, or internal failure.

5. Standby Mode: When initially attached to a utility or other power source, the UPS shall start in Standby Mode until the user initiates power to the critical load. In this mode, the UPS shall recharge the batteries, but power shall not be supplied to the critical load.

E. TVSS Rating: Total energy rating more than 520J, 320V/130J MOV from L-N, L-G, and N-G.

F. Input Voltage: 90-138 VAC, 45 to 65 Hz.

G. Output Power Factor: 0.9.

H. Input Line Cord: 6-ft. attached line cord with 5-15P.

I. Output Receptacles: Six 5-15R

J. Operating Temperature: 32 to 104 degrees F.

K. Serial Communication Interfaces: RS-232 port (DB9) and USB (Universal Serial Bus) for communication to vendor-supplied Power Management Software.

L. Relay Output: Include optional Relay Output Card for status reporting to the PLC.

M. External Maintenance Bypass: Include HS-MBP.

2.02 HOT–SWAP MAINTENANCE BYPASS

A. Manufacturer and Model: Powerware HS-MBP-15 Maintenance Bypass, or equal approved by end user.

B. Rating: 1440 VA

C. Description: Power Distribution Unit (PDU) style maintenance bypass configured as follows:

1. Line cords with plugs to input line power and UPS output

2. Six receptacles for outputs to loads

3. Selector switch for normal and bypass.

PART 3: EXECUTION

3.01 INSTALLATION

A. Verify that location is suitable for UPS and HS-MBP installation.

B. Do not install UPS until building environment can be maintained within the service conditions required by the manufacturer.

3.02 RELATED INSTALLATION REQUIREMENTS

A. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.

END OF SECTION

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Section 16990

FACILITIES FOR CENTERPOINT ENERGY'S USE

PART 1: GENERAL

1.01 Section Includes:

A. Details for facilities constructed by this Contractor for CenterPoint Energy's use.

1.02 CENTERPOINT ENERGY TERMS AND CONDITIONS PACKAGE

A. CenterPoint Energy will provide a Terms and Conditions Package which outlines requirements for electric service and provides construction details for underground duct banks, conduit stub-ups at terminal poles and transformer foundations. The CenterPoint Energy Terms and Conditions Package will not be available until construction starts on the project. Preliminary copies of CenterPoint Energy standard construction details are attached to this specification for use in bidding.

1.03 CENTERPOINT ENERGY INSPECTIONS

A. All facilities constructed for CenterPoint Energy's use must be inspected by CenterPoint Energy. Make arrangements with CenterPoint Energy for inspections.

1.04 MEASUREMENT AND PAYMENT

A. No separate payment will be provided for work performed under this Section. Include the cost for this work in the lump sum base bid.

B. Refer to Section 01270 – Measurement and Payment.

PART 2 PRODUCTS

2.01 PVC CONDUIT

A. CenterPoint Energy's Terms and Conditions document, when it becomes available, will indicate the minimum grade of PVC conduit to be used is Type EB. Do not use Type EB PVC conduit, use Schedule 40 PVC conduit in CenterPoint Energy duct banks.

PART 3: EXECUTION – NOT USED

END OF SECTION