

TPWD ENCHANTED ROCK WATER SYSTEM IMPROVEMENTS

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DIVISION 1
GENERAL REQUIREMENTS

SECTION 01 11 00 - SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes description and requirements of:
 - 1. Work covered by Contract Documents.
 - 2. Activities of others within Project area.
 - 3. Coordination of Work required by Contractor.
 - 4. Provisions for future Work.

- B. Work covered by Contract Documents: The completed Work will provide Owner with a new water booster pump station. More specifically, the Project includes, but is not limited to, construction of the following:
 - 1. Booster pump station including:
 - a. Duplex pump system with associated piping
 - b. FRP structure including foundation
 - c. Two hydropneumatics pressure tanks
 - d. Tank controls and alarms as specified
 - e. HVAC components
 - 2. Yard piping improvements
 - a. New piping and valves
 - b. 3" meter replacement
 - 3. Existing piping pressure testing and repairs
 - 4. Water system communications improvements
 - 5. Lighting and gauge improvements at well sites
 - 6. Water well rehabilitation
 - 7. All other facility elements and features indicated by the drawings, by the details, and as specified herein.

- C. Except as Specifically Noted Otherwise, Provide and Pay For:
 - 1. Insurance and bonds.
 - 2. Labor, materials, and equipment.
 - 3. Tools, equipment, and machinery required for construction.
 - 4. Utilities required for construction.
 - 5. Temporary facilities including sheeting and shoring.
 - 6. Traffic control and dust control measures.
 - 7. Other facilities and services necessary for proper execution and completion of the Work.

- D. Secure and pay for all permits including all necessary permits, OSHA excavation permits, Stormwater General Permit for Construction Activities from TCEQ, and any other government fees and licenses.
 - 1. It is the Contractor's responsibility to maintain the required controls and record keeping to comply with the SWPPP and associated stormwater permit.

- E. Comply with codes, ordinances, regulations, orders, and other legal requirements of public authorities having bearing on the performance of the Work.

1.2 ACTIVITIES BY OTHERS

- A. OWNER, utilities, and others may perform activities within Project area while the Work is in progress.
 - 1. Schedule the Work with OWNER, utilities, and others to minimize mutual interference.

- B. Cooperate with Others to Minimize Interference and Delays.
 - 1. When cooperation fails, submit recommendations and perform Work in coordination with work of others as directed.
- C. Other On-Going and Potential Projects that parallel the schedule of this project:
 - 1. None

1.3 PROVISIONS FOR FUTURE WORK

- A. Provisions for future construction are as shown as detailed on drawings and in the specifications.

1.4 LOCATION OF WORK

- A. The Project is located at the Enchanted Rock State Natural Area – 16710 Ranch Road 965, Fredericksburg, TX 78624.

1.5 OWNER FURNISHED EQUIPMENT

- A. For this project's delivery, the Owner shall not be providing and/or delivering any associated equipment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 11 60 – PROJECT MANUAL LANGUAGE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes description and requirements of:
 - 1. Explanation of Project Manual arrangement.
 - 2. Explanation of Project Manual language.
 - 3. Reference standards.
 - 4. Method of resolving conflicts of referenced standards between Contract Documents.
- B. Related Documents and Sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

1.2 REFERENCES

- A. Construction Specifications Institute (CSI):
 - 1. Manual of Practice - MasterFormat™.
 - 2. Manual of Practice - SectionFormat™.
 - 3. Manual of Practice - PageFormat™.

1.3 PROJECT MANUAL ARRANGEMENT

- A. Document and Section numbers used in Project Manual, and Project Manual arrangement are in accordance with CSI MasterFormat™, except where departures have been deemed necessary.
- B. Sections are written in accordance with CSI SectionFormat™, Three-Part Section Format, except where departures have been deemed necessary.
- C. Page format for Sections in the Project Manual is in accordance with CSI Page Format, except where departures have been deemed necessary.

1.4 PROJECT MANUAL LANGUAGE

- A. Specification Section Paragraphs entitled "Section Includes" summarizes briefly what is generally included in the section. Requirements of Contract Documents are not limited by "Section Includes" paragraphs. Specifications have been partially streamlined by intentionally omitting words and phrases, such as "the CONTRACTOR shall," "in conformity therewith," "shall be" following "as indicated," "a," "an," "the" and "all". Assume missing portions by inference.
- B. Phrase "by ENGINEER" modifies words such as "accepted," "directed," "selected," "inspected," and "permitted," when they are unmodified.
- C. Phrase "to ENGINEER" modifies words such as "submit," "report," and "satisfactory," when they are unmodified.
- D. Colons (:) are used to introduce a list of particulars, an appositive, an amplification, or an illustrative quotation:
 - 1. When used as an appositive after designation of product, colons are used in place of words "shall be."

- E. Word "provide" means to manufacture, fabricate, deliver, furnish, install, complete, assemble, erect in place, test, render ready for use or operation, including necessary related material, labor, appurtenances, services, and incidentals.
- F. Words "CONTRACTOR shall" are implied when direction is stated in imperative mood.
- G. Term "products" includes materials and equipment as specified in Section 01 60 00.

1.5 REFERENCE STANDARDS

- A. Use only applicable portions of referenced standards, ignoring payment stipulations and other provisions which change the duties of the ENGINEER or OWNER.
- B. Equate terms relating to designer to "ENGINEER."
- C. Notify ENGINEER when referenced standard, code, or specification conflicts with Contract Documents.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 14 00 – WORK RESTRICTIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes description and requirements of:
 - 1. General constraints for sequencing and scheduling the Work.
 - 2. Interruption of Treatment Processes.
 - 3. Compliance with National/Texas Pollutant Discharge Elimination System Permit.
 - 4. Work affected by existing site and facility.
 - 5. Work restrictions and coordination between construction operations and plant operations, including:
 - a. Access to site.
 - b. Use of site and premises.
 - c. Utilities.
 - d. Work by Others.
 - e. Work Sequence.
 - f. Temporary Services, Materials and Equipment.
- B. Related sections:
 - 1. Section 01 11 00 - Summary of Work.
 - 2. Section 01 26 00 - Contract Modification Procedures.
 - 3. Section 01 50 00 - Temporary Facilities and Controls.

1.2 GENERAL CONSTRAINTS ON SEQUENCE AND SCHEDULING OF WORK

- A. Water Projects:
 - 1. The water distribution for the Enchanted Rock State Natural Area delivers potable water to visitors and operational and maintenance facilities at the State Park. Any required shutdown of the supply of water to the system shall be coordinated with the Owner and Engineer in writing before a required shutdown.
 - 2. The Contractor shall limit shutdowns as much as possible.
 - 3. Shutdowns for tie-ins or repairs of the water system shall be scheduled in off-peak times as coordinated with the Owner.
- B. Work Sequence and Constraints:
 - 1. Utilize description of critical events in work sequence in this Section as a guideline for scheduling and undertaking the Work.

2. Work sequence and constraints presented do not include all items affecting completion of the Work, but are intended to describe critical events necessary to minimize disruption of the existing facilities.

1.3 INTERRUPTION OF FACILITY PROCESSES

- A. Execute the Work while the existing facility is in operation.
- B. Indicate required shutdowns of existing facilities or interruptions of existing operations on Progress Schedule. Shutdowns will be permitted to the extent that existing operation will not be jeopardized and identified constraints are satisfied.
- C. Submit written notification of required shutdowns of existing facilities at least 7 days prior to the planned date of shutdown.
- D. The engineer and the facility personnel will evaluate the request based on the pump stations' ability to reliably meet capacity demands.
- E. Do not begin alterations until engineer's written permission has been received.
- F. Minimize shutdown times by thorough advanced planning. Have required equipment, materials, and labor on hand at time of shutdown.
- G. Where required to minimize process interruptions while complying with specified sequencing constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.

1.4 REQUIREMENTS FOR OPERATION OF SYSTEM AND MAINTAINING CONTINUOUS OPERATION OF EXISTING FACILITIES

- A. Facilities or conditions required to keep the distribution system operational include, but are not limited to, the following:
 1. Electrical power
 2. All existing pumps.
 3. Disinfection Facility
 4. Lighting.
 5. Instrumentation, meters, controls, and telemetry equipment.
 6. Safety equipment and features.
- B. Conduct the Work and provide temporary facilities required to keep the existing tank and distribution piping in operation during construction.

1.5 OPERATIONS AND MAINTENANCE ACCESS

- A. Provide safe, continuous access to process control equipment for pump station operations personnel.

1.6 SHUTDOWN CONSTRAINTS

- A. Comply with Shutdown Constraints as follows:
 - 1. Provide 7 days advance notice to Engineer and Owner of need for a shutdown of less than 8 hours.
 - 2. Provide 30 days advance notice to Engineer and Owner of need for a shutdown of greater than 8 hours.
 - 3. Shutdowns less than 8 hours will be allowed, but will be limited to low demand periods as agreed upon by Owner.
 - 4. Any shutdowns shall require a shutdown plan, including detailed schedule, backup tools and equipment, personnel involved, contingency plan, and any procedures involved in restarting the process or facility. Owner's approval of the Shutdown Plan is required prior to any shutdowns.

1.7 UTILITIES

- A. Provide advance notice to and utilize services of 811 for location and marking of underground utilities operated by utility agencies other than the Owner. Contact information: Call 811 for marking of utilities.
- B. Maintain electrical, telephone, water, gas, sanitary facilities, and other utilities within existing facilities in service. Provide temporary utilities when necessary.

1.8 WORK BY OTHERS

- A. Where proper execution of the Work depends upon work by others, inspect and promptly report discrepancies and defects.

1.9 WORK SEQUENCE

- A. The project schedule assumes that all project efforts will be delivered in a concurrent, logical fashion. The following sequences does not detail the integration of all work included in the Contract. The Contractor is responsible to perform all required work and coordinate that work with the continuing appropriate operation of the existing facilities. This possible sequence is included for informational purposes only.
 - 1. The anticipated sequence of events at the Enchanted Rock State Natural Area is as follows:
 - a. Site preparation
 - b. Yard piping construction and tie-ins. Tie-ins to existing line shall be planned to require the shortest shut-down times possible and shall be coordinated with Owner and Engineer.
 - c. Booster pump station construction and electrical improvements
 - d. Pressure testing of existing park water system
 - e. Complete site work, and final clean-up.

1.10 TEMPORARY SERVICES, MATERIALS, AND EQUIPMENT

- A. Locate temporary facilities in a manner that minimizes interference to Owner's operation and maintenance personnel.
- B. Unless otherwise specified, install temporary pipelines of the same size as its connection to the existing facility at the downstream end of the pipeline.
- C. Provide piping of suitable material for the material being conveyed.
- D. Provide submittals on proposed temporary electrical and instrumentation components necessary to maintain existing facilities.
- E. Dewater and promptly clean basins and channels temporarily removed from service.
- F. Dimensions for all existing structures, piping, paving, and other nonstructural items are approximate. The Contractor shall field verify all dimensions and conditions and report any discrepancies to the Engineer a minimum of 14 days in advance of any construction in the area.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 32 90 – SAFETY PLAN

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Development and maintenance of a Construction Safety Plan.

1.2 REFERENCES

- A. OSHA.

1.3 CONSTRUCTION SAFETY PLAN

- A. Detail the Methods and Procedures to comply with Federal, and Local Health and Safety Laws, Rules and Requirements for the duration of the Contract Times. Include the following:
 1. Identification of the Certified or Licensed Safety Consultant, who will prepare, initiate, maintain and supervise safety programs, and procedures.
 2. Procedures for providing workers with an awareness of safety and health hazards expected to be encountered in the course of construction.
 3. Safety equipment appropriate to the safety and health hazards expected to be encountered during construction. Include warning devices, barricades, safety equipment in public right-of-way and protected areas, and safety equipment used in multi-level structures.
 4. Methods for minimizing employees' exposure to safety and health hazards expected during construction.
 5. Procedures for reporting safety or health hazards.
 6. Procedures to follow to correct a recognized safety and health hazard.
 7. Procedures for investigation of accidents, injuries, illnesses and unusual events that have occurred at the construction site.
 8. Periodic and scheduled inspections of general work areas and specific work stations.
 9. Training for employees and workers at the jobsite.
 10. Methods of communication of safe working conditions, work practices and required personal protection equipment.
- B. Assume responsibility for every aspect of Health and Safety on the jobsite, including the health and safety of subcontractors, suppliers, and other persons on the jobsite:
 1. Forward available information and reports to the Safety Consultant who shall make the necessary recommendations concerning worker health and safety at the jobsite.
 2. Employ additional health and safety measures specified by the Safety Consultant, as necessary, for workers in accordance with OSHA guidelines.
- C. Transmit to Owner and Engineer copies of reports and other documents related to accidents or injuries encountered during construction.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 42 00 - REFERENCES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes description and requirements of:
 - 1. References to Standards and Specifications of Technical Societies
 - 2. Abbreviations used to reference Technical Societies

1.2 REFERENCE TO STANDARDS AND SPECIFICATIONS OF TECHNICAL SOCIETIES

- A. Reference to standards and specifications of technical societies and reporting and resolving discrepancies associated therewith shall be as provided in the General Conditions, and as may otherwise be required herein and in the individual Specification sections.
- B. Work specified by reference to published standard or specification of government agency, technical association or trade association, professional society or institute, testing agency, or other organization shall meet requirements or surpass minimum standards of quality for materials and workmanship established by designated standard or specification.
- C. Where so specified, products or workmanship shall also meet or exceed additional prescriptive or performance requirements included within Contract Documents to establish a higher or more stringent standard of quality than required by referenced standard.
- D. Where two or more standards are specified to establish quality, product and workmanship shall meet or exceed requirements of most stringent.
- E. Where both a standard and a brand name are specified for a product in Contract Documents, proprietary product named shall meet or exceed requirements of specified reference standard.
- F. Copies of Standards and Specifications of Technical Societies:
 - 1. Copies of applicable referenced standards have not been bound in these Contract Documents.
 - 2. Where copies of standards are needed by Contractor, obtain a copy or copies directly from publication source and maintain in an orderly manner at the Site as Work Site records, available to Contractor's personnel, Subcontractors, Owner, and Engineer.

1.3 ABBREVIATIONS

- A. Abbreviations for trade organizations and government agencies: Following is a list of construction industry organizations and government agencies to which references may be made in the Contract Documents, with abbreviations used.
 - 1. AA Aluminum Association
 - 2. AABC Associated Air Balance Council
 - 3. AAMA American Architectural Manufacturers Association
 - 4. AASHTO American Association of State Highway and Transportation Officials
 - 5. ABMA American Bearing Manufacturers' Association
 - 6. ACI American Concrete Institute
 - 7. AEIC Association of Edison Illuminating Companies
 - 8. AGA American Gas Association
 - 9. AGMA American Gear Manufacturers' Association
 - 10. AI Asphalt Institute
 - 11. AISC American Institute of Steel Construction
 - 12. AISI American Iron and Steel Institute

13.	AITC	American Institute of Timber Construction
14.	ALS	American Lumber Standards
15.	AMCA	Air Movement and Control Association
16.	ANSI	American National Standards Institute
17.	APA	The Engineered Wood Association
18.	API	American Petroleum Institute
19.	APWA	American Public Works Association
20.	ARI	Air-Conditioning and Refrigeration Institute
21.	ASAE	American Society of Agricultural Engineers
22.	ASCE	American Society of Civil Engineers
23.	ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
24.	ASME	American Society of Mechanical Engineers
25.	ASNT	American Society for Nondestructive Testing
26.	ASTM	ASTM International
27.	AWI	Architectural Woodwork Institute
28.	AWPA	American Wood Preservers' Association
29.	AWPI	American Wood Preservers' Institute
30.	AWS	American Welding Society
31.	AWWA	American Water Works Association
32.	BHMA	Builders Hardware Manufacturers' Association
33.	CBM	Certified Ballast Manufacturer
34.	CDA	Copper Development Association
35.	CGA	Compressed Gas Association
36.	CIS PI	Cast Iron Soil Pipe Institute
37.	CMAA	Crane Manufacturers' Association of America
38.	CRSI	Concrete Reinforcing Steel Institute
39.	CS	Commercial Standard
40.	CSA	Canadian Standards Association
41.	CSI	Construction Specifications Institute
42.	DIN	Deutsches Institute für Normung e.V.
43.	DIPRA	Ductile Iron Pipe Research Association
44.	EIA	Electronic Industries Alliance
45.	EJCDC	Engineers Joint Contract Documents' Committee
46.	ETL	Electrical Test Laboratories
47.	FAA	Federal Aviation Administration
48.	FCC	Federal Communications Commission
49.	FDA	Food and Drug Administration
50.	FEMA	Federal Emergency Management Agency
51.	FIPS	Federal Information Processing Standards
52.	PM	Factory Mutual
53.	Fed. Spec.	Federal Specifications (FAA Specifications)
54.	FS	Federal Specifications and Standards (Technical Specifications)
55.	GA	Gypsum Association
56.	GANA	Glass Association of North America
57.	ID	Hydraulic Institute
58.	HMI	Hoist Manufacturers' Institute
59.	IBC	International Building Code
60.	ICBO	International Conference of Building Officials
61.	ICC	International Code Council
62.	ICEA	Insulated Cable Engineers' Association
63.	IFC	International Fire Code
64.	IEEE	Institute of Electrical and Electronics Engineers, Inc.
65.	IESNA	Illuminating Engineering Society of North America
66.	IFI	Industrial Fasteners Institute
67.	IGMA	Insulating Glass Manufacturer's Alliance

68.	IMC	International Mechanical Code
69.	INDA	Association of the Non-woven Fabrics Industry
70.	IPC	International Plumbing Code
71.	ISA	Instrumentation, Systems, and Automation
72.	ISO	International Organization for Standardization
73.	ITL	Independent Testing Laboratory
74.	JIC	Joint Industry Conferences of Hydraulic Manufacturers
75.	MIA	Marble Institute of America
76.	Mil.	Military Specifications
77.	MMA	Monorail Manufacturers' Association
78.	NAAMM	National Association of Architectural Metal Manufacturers
79.	NACE	NACE International
80.	NEBB	National Environmental Balancing Bureau
81.	NEC	National Electrical Code
82.	NECA	National Electrical Contractors Association
83.	NEMA	National Electrical Manufacturers' Association
84.	NESC	National Electrical Safety Code
85.	NETA	International Electrical Testing Association
86.	NFPA	National Fire Protection Association
87.	NHLA	National Hardwood Lumber Association
88.	NICET	National Institute for Certification in Engineering Technologies
89.	NIST	National Institute of Standards and Technology
90.	NRCA	National Roofing Contractors Association
91.	NRTL	Nationally Recognized Testing Laboratories
92.	NSF	NSF International
93.	NSPE	National Society of Professional Engineers
94.	NTMA	National Terrazzo and Mosaic Association
95.	NWWDA	National Wood Window and Door Association
96.	OSHA	Occupational Safety and Health Act (both Federal and State)
97.	PCI	Pre-cast/Pre-stressed Concrete Institute
98.	PEI	Porcelain Enamel Institute
99.	PPI	Plastic Pipe Institute
100.	PS	Product Standards Section-U.S. Department of Commerce
101.	RMA	Rubber Manufacturers' Association
102.	RUS	Rural Utilities Service
103.	SAE	Society of Automotive Engineers
104.	SDI	Steel Deck Institute
105.	SDI	Steel Door Institute
106.	SJI	Steel Joist Institute
107.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
108.	SPI	Society of the Plastics Industry
109.	SSPC	The Society for Protective Coatings
110.	SWI	Steel Window Institute
111.	TEMA	Tubular Exchanger Manufacturers' Association
112.	TCA	Tile Council of North America
113.	TIA	Telecommunications Industry Association
114.	UBC	Uniform Building Code
115.	UFC	Uniform Fire Code
116.	UL	Underwriters Laboratories Inc.
117.	UMC	Uniform Mechanical Code
118.	USBR	U.S. Bureau of Reclamation
119.	WCLIB	West Coast Lumber Inspection Bureau
120.	WWPA	Western Wood Products Association

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 42 40 – ABBREVIATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Abbreviations and meanings.

1.2 INTERPRETATIONS

- A. Interpret abbreviations by context in which abbreviations are used.

1.3 ABBREVIATIONS

A. Abbreviations Used to Identify Reference Standards:

1. AA Aluminum Association
2. AAMA Architectural Aluminum Manufacturers Association
3. AAN American Association of Nurserymen
4. AASHTO American Association of State Highway and Transportation Officials
5. ABC Associated Air Balance Council
6. ABPA Acoustical and Board Products Association
7. ACI American Concrete Institute
8. ACIL American Council of Independent Laboratories
9. ADC Air Diffusion Council
10. ABMA American Bearing Manufacturers' Association (formerly AFBMA, Anti-Friction Bearing Manufacturers' Association)
11. AGA American Gas Association
12. AGC Associated General Contractors
13. AGMA American Gear Manufacturers' Association
14. AI Asphalt Institute
15. AIA American Institute of Architects
16. AIMA Acoustical and Insulating Materials Association
17. AISC American Institute of Steel Construction
18. AISI American Iron and Steel Institute
19. AITC American Institute of Timber Construction
20. AMCA Air Moving and Conditioning Association
21. AMG Arizona Masonry Guild
22. ANSI American National Standards Institute
23. APA American Plywood Association
24. API American Petroleum Institute
25. ARI Air Conditioning and Refrigeration Institute
26. ASAHCA American Society of Architectural Hardware Consultants
27. ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
28. ASME American Society of Mechanical Engineers
29. ASTM ASTM International (Former name American Society for Testing and Materials. Still used in specifications.)
30. AWI Architectural Woodwork Institute
31. AWPA American Wood Preservers Association
32. AWPI American Wood Preservers Institute
33. AWS American Welding Society
34. AWSC American Welding Society Code
35. AWWA American Water Works Association
36. BHMA Builders Hardware Manufacturers Association
37. BIA Brick Institute of America
38. BSI Building Stone Institute

39.	CLFMI	Chain Link Fence Manufacturers Institute
40.	CPSC	U.S. Consumer Product Safety Commission
41.	CRA	California Redwood Association
42.	CRI	Carpet and Rug Institute
43.	CRSI	Concrete Reinforcing Steel Institute
44.	CS	Commercial Standards
45.	CSI	Construction Specifications Institute
46.	CTI	Ceramic Tile Institute
47.	DHI	Door and Hardware Institute
48.	EIFS	Exterior Insulation and Finish System
49.	EJCDC	Engineers Joint Contract Documents Committee
50.	FGMA	Flat Glass Marketing Association
51.	FIA	Factory Insurance Association
52.	FM	Factory Mutual
53.	FS	Federal Specifications
54.	FTI	Facing Tile Institute
55.	GA	Gypsum Association
56.	IAPMO	International Association of Plumbing and Mechanical Officials
57.	IBC	International Building Code
58.	ICBO	International Conference of Building Officials
59.	ICC	International Code Council
60.	IEEE	Institute of Electrical and Electronics Engineers
61.	MAG	Maricopa Association of Governments
62.	MIA	Marble Institute of America
63.	ML/SFA	Metal Lath/Steel Framing Association
64.	MS	Military Specifications
65.	NAAMM	National Association of Architectural Metal Manufacturers
66.	NAPA	National Asphalt Pavement Association
67.	NBHA	National Builders Hardware Association
68.	NCMA	National Concrete Masonry Association
69.	NEC	National Electrical Code
70.	NECA	National Electrical Contractors Association
71.	NETA	International Electrical Testing Association
72.	NEMA	National Electrical Manufacturers Association
73.	NFPA	National Fire Protection Association
74.	NFPA	National Forest Products Association
75.	NIST	National Institute of Standards and Technology
76.	NMWIA	National Mineral Wood Insulation Association
77.	NPCA	National Paint and Coatings Association
78.	NRCA	National Roofing Contractors Association
79.	NTMA	National Terrazzo and Mosaic Association
80.	NWMA	National Woodwork Manufacturer's Association
81.	PCA	Portland Cement Association
82.	PCI	Prestressed Concrete Institute
83.	PDCA	Paint and Decorating Contractors of America
84.	PDI	Plumbing and Drainage Institute
85.	PEI	Porcelain Enamel Institute
86.	PS	Product Standard
87.	RTI	Resilient Tile Institute
88.	SAE	Society of Automotive Engineers
89.	SCPA	Structural Clay Products Association
90.	SDI	Steel Door Institute
91.	SIGMA	Sealed Insulating Glass Manufacturers Association
92.	SJI	Steel Joist Institute
93.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
94.	SSPC	Society for Protective Coatings-Steel Structures Painting Council

95.	TCA	Tile Council of America
96.	UBC	Uniform Building Code (ICBO)
97.	UL	Underwriters Laboratories, Inc.
98.	UNS	Unified Numbering System
99.	USDA	United States Department of Agriculture
100.	VA	Vermiculite Association
101.	WCLA	West Coast Lumberman's Association
102.	WCLIB	West Coast Lumber Inspection Bureau
103.	WPA	Western Pine Association
104.	WPOA	Western Plumbing Officials Association
105.	WRC	Welding Research Council
106.	WSCPA	Western States Clay Products Association
107.	WWPA	Western Wood Products Association

B.	B.	Abbreviations Used in Specifications:
1.	a	year or years (metric unit)
2.	A	ampere or amperes
3.	am	ante meridian (before noon)
4.	ac	alternating current
5.	ac-ft	acre-foot or acre-feet
6.	atm	atmosphere
7.	AWG	American Wire Gauge
8.	bbl	barrel or barrels
9.	bd	board
10.	bhp	brake horsepower
11.	bil gal	billion gallons
12.	BOD	biochemical oxygen demand
13.	Btu	British thermal unit or units
14.	Btuh	British thermal units per hour
15.	bu	bushel or bushels
16.	C	degrees Celsius
17.	cal	calorie or calories
18.	cap	capita
19.	cd	candela or candelas
20.	cfm	cubic feet per minute
21.	Ci	curie or curies
22.	cm	centimeter or centimeters
23.	cmu	concrete masonry unit
24.	CO	carbon monoxide
25.	Co.	Company
26.	CO ₂	carbon dioxide
27.	COD	chemical oxygen demand
28.	Corp.	Corporation
29.	counts/min	counts per minute
30.	cu	cubic
31.	cu cm	cubic centimeter or centimeters
32.	cu ft	cubic foot or feet
33.	cu ft/day	cubic feet per day
34.	cu ft/hr	cubic feet per hour
35.	cu ft/min	cubic feet per minute
36.	cu ft/sec	cubic feet per second
37.	cu in	cubic inch or inches
38.	cu m	cubic meter or meters
39.	cu yd	cubic yard or yards
40.	d	day (metric units)
41.	day	day (English units)

42.	db	decibels
43.	DB	dry bulb (temperature)
44.	dc	direct current
45.	diam	diameter
46.	DO	dissolved oxygen
47.	DS	dissolved solids
48.	emf	electromotive force
49.	fpm	feet per minute
50.	F	degrees Fahrenheit
51.	ft	feet or foot
52.	fc	foot-candle or foot candles
53.	ft/day	feet per day
54.	ft/hr	feet per hour
55.	ft/min	feet per minute
56.	ft/sec	feet per second
57.	g	gram or grams
58.	G	gravitational force
59.	gal	gallon or gallons
60.	gal/day	gallons per day
61.	gal/min	gallons per minutes
62.	gal/sec	gallons per second
63.	gfd	gallons per square foot per day
64.	g/L	grams per liter
65.	gpd	gallons per day
66.	gpd/ac	gallons per day per acre
67.	gpd/cap	gallons per day per capita
68.	gpd/sq ft	gallons per day per square foot
69.	gph	gallons per hour
70.	gpm	gallons per minute
71.	gps	gallons per second
72.	h	hour or hours (metric units)
73.	ha	hectare or hectares
74.	hp	high point
75.	hp	horsepower
76.	hp-hr	horsepower-hour or horsepower-hours
77.	hr	hour or hours (English units)
78.	Hz	hertz
79.	ID	inside diameter
80.	ihp	indicated horsepower
81.	Inc.	Incorporated
82.	inch	inch
83.	inches	inches
84.	inches/sec	inches per second
85.	J	joule or joules
86.	JTU	Jackson turbidity unit or units
87.	k	kips
88.	K	kelvin
89.	K	thermal conductivity
90.	kcal	kilocalorie or kilocalories
91.	kcmil	thousand circular mils
92.	kg	kilogram or kilograms
93.	km	kilometer or kilometers
94.	kN	kilonewton or kilonewtons
95.	kPa	kilopascal or kilopascals
96.	ksi	kips per square inch
97.	kV	kilovolt or kilovolts

98.	kVA	kilovolt-ampere or kilovolt-amperes
99.	kW	kilowatt or kilowatts
100.	kWh	kilowatt hour
101.	L	liter or liters
102.	lb/1000 cu ft	pounds per thousand cubic foot
103.	lb/acre-ft	pounds per acre-foot
104.	lb/ac	pounds per acre
105.	lb/cu ft	pounds per cubic foot
106.	lb/day/cu ft	pounds per day per cubic foot
107.	lb/day/acre	pounds per day per acre
108.	lb/sq ft	pounds per square foot
109.	lin	linear, lineal
110.	lin ft	linear foot or feet
111.	lm	lumen or lumens
112.	log	logarithm (common)
113.	ln	logarithm (natural)
114.	lx	lux
115.	m	meter or meters
116.	M	molar (concentration)
117.	mA	milliamperere or milliamperes
118.	max	maximum
119.	mCi	millicurie or millicuries
120.	meq	milliequivalent
121.	µF	microfarad or microfarads
122.	MFBM	thousand feet board measure
123.	mfr	manufacturer
124.	mg	milligram or milligrams
125.	mgd/ac	million gallons per day per acre
126.	mgd	million gallons per day
127.	mg/L	milligrams per liter
128.	µg/L	micrograms per liter
129.	µm	micrometer or micrometers
130.	mile	mile
131.	mil. gal	million gallons
132.	miles	miles
133.	min	minimum
134.	min	minute or minutes
135.	MLSS	mixed liquor suspended solids
136.	MLVSS	mixed liquor volatile suspended solids
137.	mm	millimeter or millimeters
138.	mol wt	molecular weight
139.	mol	mole
140.	Mpa	megapascal or megapascals
141.	mph	miles per hour
142.	MPN	most probable number
143.	mR	milliroentgen or milliroentgens
144.	Mrad	megarad or megarads
145.	mV	millivolt or millivolts
146.	MW	megawatt or megawatts
147.	N	newton or newtons
148.	N	normal (concentration)
149.	No.	number
150.	Nos	numbers
151.	NRC	noise reduction coefficient
152.	NTU or ntu	nephelometric turbidity unit
153.	oc	on center

154.	OD	outside diameter
155.	ORP	oxidation-reduction potential
156.	OT	ortho-tolidine
157.	OTA	ortho-tolidine-arsenite
158.	oz	ounce or ounces
159.	oz/sq ft	ounces per square foot
160.	Pa	pascal or pascals
161.	pl	plate or property line
162.	pm	post meridiem (afternoon)
163.	ppb	parts per billion
164.	ppm	parts per million
165.	ppt	parts per thousand
166.	pr	pair
167.	psf/hr	pounds per square foot per hour
168.	psf	pounds per square foot
169.	psi	pounds per square inch
170.	psia	pounds per square inch absolute
171.	psig	pounds per square inch gauge
172.	PVC	polyvinyl chloride
173.	qt	quart or quarts
174.	R	radius
175.	R	roentgen or roentgens
176.	rad	radiation absorbed dose
177.	RH	relative humidity
178.	rpm	revolutions per minute
179.	rps	revolutions per second
180.	S	second (metric units)
181.	S	Siemens (mho)
182.	SDI	sludge density index or silt density index
183.	sec	second (English units)
184.	SI	International System of Units
185.	sp	static pressure
186.	sp gr	specific gravity
187.	sp ht	specific heat
188.	sq	square
189.	cm ² or sq cm	square centimeter or centimeters
190.	sq ft	square feet or foot
191.	sq inch	square inch
192.	sq inches	square inches
193.	km ² or sq km	square kilometer or kilometers
194.	m ² or sq m	square meter or meters
195.	mm ² or sq mm	square millimeter or millimeters
196.	sq yd	square yard or yards
197.	SS	suspended solids
198.	STC	Sound Transmission Class
199.	SVI	sludge volume index
200.	TDS	total dissolved solids
201.	TKN	total Kjeldahl nitrogen
202.	TLM	median tolerance limit
203.	TOC	total organic carbon
204.	TOD	total oxygen demand
205.	TOW	top of weir
206.	TS	total solids
207.	TSS	total suspended solids
208.	TVS	total volatile solids

209.	U	U Factor/U Value
210.	U	Coefficient of Heat Transfer
211.	U	heat transfer coefficient
212.	UNS	Uniform Numbering System
213.	US	United States
214.	V	volt or volts
215.	VA	volt-ampere or volt-amperes
216.	W	watt or watts
217.	WB	wet bulb
218.	wg	water gauge
219.	wk	week or weeks
220.	wt	weight
221.	yd	yard or yards
222.	yr	year or years (English unit)

C. Abbreviations Used on Drawings: As listed on Drawings or in Specifications.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 81 02 – SEISMIC DESIGN CRITERIA

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Seismic design criteria for the following:
 - 1. Anchorage of mechanical and electrical equipment.
 - 2. Seismic design and design of anchorage for small tanks fabricated off site and shipped to the Project site.
 - 3. Other structures or items as specified or indicated on the Drawings.

1.2 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. ASCE 7 - Minimum Design Loads for Buildings and Other Structures

1.3 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Design in accordance with the requirements of the building code as specified
 - a. Soil Site Class: D
 - b. Design spectral acceleration at short period, S_{DS} : 0.274g.
 - c. Design spectral acceleration at short period, S_{D1} : 0.123g.
 - d. Seismic Design Category: B
 - e. Importance Factor, I : 1.25
 - f. Component amplification factor, a_p : In accordance with ASCE 7-05, Tables 13.5.1 and 13.6-1.
 - g. Component response modification factor, R_p : In accordance with ASCE 7 05, Tables 13.5-1 and 13.6-1.
 - h. Component importance factor, I_p : 1.50.
 - 2. Do not use friction to resist sliding due to seismic forces.
 - 3. Do not use more than 60 percent of the weight of the mechanical and electrical equipment for designing anchors for resisting overturning due to seismic forces.
 - 4. Do not use more than 60 percent of the weight of the tank for resisting overturning due to seismic forces.
 - 5. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic forces. Anchor bolts used to resist seismic forces shall have a standard hex bolt head embedded in the concrete. Do not use anchor bolts fabricated from rod stock with an L or J shape.
 - 6. Do not use chemical anchors, concrete anchors, flush shells, powder actuated fasteners, sleeve anchors, or other types of anchors unless indicated on the Drawings or accepted in writing by the ENGINEER.
 - 7. Seismic forces must be resisted by direct bearing on the fasteners used to resist seismic forces. Do not use connections that use friction to resist seismic forces.

1.4 SUBMITTALS

- A. Shop drawings and calculations: Complete shop drawings and seismic calculations.
- B. Calculations shall be signed and stamped by a civil or structural engineer licensed in the state where the Project is located.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

SECTION 01 81 04 – WIND DESIGN CRITERIA

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Wind design criteria.
- B. Related sections:
 - 1. Section 01 41 00 – Regulatory Requirements.

1.2 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Building code criteria: Design for wind in accordance with building code as specified.
 - a. Risk Category: III.
 - b. Basic wind speed: 120 miles per hour.
 - c. Exposure category: C.
 - d. Topographic factor, K_{zt} : 1.0.
Use anchor bolts, bolts, or welded studs for anchors for resisting wind forces. Anchor bolts used to resist wind forces shall have a standard hex bolt head embedded in the concrete. Do not use anchor bolts fabricated from rod stock with an L or J shape:
 - e. Do not use concrete anchors, sleeve anchors, flush shells, chemical anchors, powder actuated fasteners, or other types of anchor unless indicated on the Drawings or accepted in writing by the ENGINEER.
 - f. Wind forces must be resisted by direct bearing on the anchors used to resist wind forces. Do not use connections which use friction to resist wind forces.

1.3 SUBMITTALS

- A. Shop drawings and calculations: Complete shop drawings and seismic calculations.
- B. Calculations shall be signed and stamped by a civil or structural engineer licensed in the state where the Project is located.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

DIVISION 3
CONCRETE

SECTION 03 11 00 - CONCRETE FORMING

PART 1 - GENERAL

1.1 SUMMARY

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete forming. The Work also includes:
 - a. Designing forming systems in accordance with requirements of ACI 347 and the Contract Documents.
 - b. Providing forming to accommodate the Work under this and other Sections and building into forming items such as sleeves, anchorage devices, inserts, pipe embedments, reinforcing, and all other items to be embedded in concrete for which placement is not specifically provided under other Sections.

B. Coordination:

1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before concrete forming Work.
2. Coordinate forming Specifications with requirements for finished surfaces specified in Section 03 30 00, Cast-In-Place Concrete.

C. Related Sections:

1. Section 03 15 00 - Concrete Accessories.
2. Section 03 30 00 - Cast-In-Place Concrete.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. ACI 117, Specifications for Tolerances for Concrete Construction and Materials and Commentary.
2. ACI 301, Specifications for Structural Concrete.
3. ACI 347, Guide to Formwork for Concrete.
4. ASTM C805/C805M, Test Method for Rebound Number of Hardened Concrete.
5. ASTM C1074, Practice for Estimating Concrete Strength by the Maturity Method.
6. NIST PS 1, Structural Plywood.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Professional Engineer:
 - a. CONTRACTOR or formwork Supplier shall retain a registered professional engineer legally qualified to practice in same state as the Site. Professional engineer shall have at least five years' experience designing formwork and falsework of the type required.
 - b. Responsibilities include:
 - 1) Reviewing formwork and falsework performance and design criteria stated in the Contract Documents.
 - 2) Preparing written requests for clarifications or interpretations of performance or design criteria for submittal to ENGINEER by CONTRACTOR.
 - 3) Preparing or supervising preparation of design calculations verifying compliance of formwork and falsework with requirements of the Contract Documents.
 - 4) Signing and sealing all calculations.
 - 5) Certifying that:

- a) Design of formwork and falsework was performed in accordance with performance and design criteria stated in the Contract Documents, and
 - b) Design conforms to all Laws and Regulations, and to prevailing standards of practice.
 - c) In place falsework, prior to concrete placement, complies with the intent of the forming design and complies with the Contract Documents.
- B. Mock-Ups for Concrete Finishes: Provide forming for mock-ups as required for finish work shown and specified for the Work. Place embedded materials in mock-up. Construct forms using facing materials such as form liners, where required, to provide specified finishes and to the requirements specified in Section 03 30 00, Cast-In-Place Concrete. Obtain ENGINEER'S acceptance of each mock-up prior to starting forming for the Work. Do not remove mock-up(s) until directed by ENGINEER.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Samples:

- a. Plywood form material used for smooth form finish, four inches square minimum.
- b. Form liner section sufficiently large to show two full repeating patterns, at least 12 inches square.
- c. Form Liner Sample Panel:
 - 1) Sample shall show texture and surface pattern, required backing, form tie treatment, and treatment at liner panel joints. Use form material to be used in the Work.
 - 2) Minimum Size: Three feet by four feet.

B. Informational Submittals: Submit the following:

- 1. Shop Drawings: When requested by ENGINEER, submit Shop Drawings showing and indicating general construction of individual forms, including:
 - a. Jointing.
 - b. Special formed joints or reveals.
 - c. Location, pattern, and details of form tie placement, removal, and repair procedures.
 - d. Location and details for temporary openings.
 - e. Void-form layout drawings and details of installation.
 - f. Other items that would visually affect the finished concrete.
- 2. Design of Temporary Measures: Design of formwork and falsework is CONTRACTOR'S responsibility. Submit the following:
 - a. Falsework layout drawings with the seal and signature of CONTRACTOR'S or Supplier's professional engineer. Layout drawings shall show bracing details, waler arrangements, location of shores, joint forming details, and details at connections to previously placed concrete. ENGINEER'S review will be for general conformance to the requirements of the Contract Documents and ACI 347, as indicated for delegated design in the General Conditions.
 - b. Design calculations for formwork and falsework, when requested by ENGINEER.
 - c. Certification letter from CONTRACTOR'S or Supplier's professional engineer stating that in-place falsework was inspected and complies with the intent of the falsework design.
- 3. Product Data: Manufacturer's data for proprietary materials, including form coatings, manufactured form systems, ties and accessories.
- 4. Manufacturer's Instructions: Installation instructions for proprietary materials, including form coatings, manufactured form systems, ties and accessories.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery and Storage:

1. Upon delivery to the Site, place materials in area protected from weather.
2. Store materials in accordance with manufacturer's recommendations.
3. Store materials above ground on framework or blocking. Cover wood for forms and other accessory materials with protective, waterproof covering. Provide for adequate air circulation or ventilation under cover.

B. Handle materials in accordance with the manufacturers' recommendations. Do not damage materials during handling.

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

A. Design Criteria:

1. Design, erect, support, brace and maintain forming in accordance with ACI 347 so that forming safely supports vertical and lateral loads that might be applied, until such loads can be supported by the concrete structure. Carry vertical and lateral loads to ground by forming system or in-place construction that has attained adequate strength for the purpose. Construct forming so that concrete members and structures are of correct size, shape, alignment, elevation, and position.
2. Design forms and falsework to include values of live load, dead load, weight of moving equipment operated on forming, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability, and other factors pertinent to safety of structure during construction.
3. Provide shores and struts with positive means of adjustment capable of taking up forming settlement during concrete placing operations, using wedges or jacks, or a combination thereof. Provide trussed supports when adequate foundations for shores and struts cannot be secured.
4. Support form facing materials by structural members spaced sufficiently close to prevent beyond tolerance deflection, in accordance with ACI 117. Fit forms placed in successive units for continuous surfaces to accurate alignment, free from irregularities and within allowable tolerances. For long-span members without intermediate supports, provide camber in forming as required for anticipated deflections resulting from weight and pressure of fresh concrete and construction loads.
5. Design and construct forming to be readily removable without impact, shock or damage to concrete surfaces and adjacent materials.
6. Provide forming sufficiently tight to prevent leakage of cement paste during concrete placing. Solidly butt joints and provide backup material at joints as required to prevent leakage and fins.

2.2 FORM MATERIALS

A. Forms for Smooth Finish Concrete:

1. Unless otherwise shown or indicated in the Contract Documents, construct forming for smooth concrete surfaces with plywood, metal, metal-framed plywood-faced, or other panel type materials acceptable to ENGINEER, to provide continuous, straight, smooth as-cast surfaces with no wood grain or other surface texture imparted by forming. Provide in largest practical sizes to minimize number of joints and to conform to joint system shown or specified in the Contract Documents. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.

- B. Forms for Standard Finish Concrete:
1. Form concrete surfaces designated to have standard formed finish with plywood, lumber, metal, or other acceptable material. Provide lumber that is dressed on at least two edges and one side.
- C. Forms for Architecturally Finished Concrete:
1. Form finish concrete surfaces with units of face design, size, arrangement, and configuration as shown or as required to comply with approved Project job mock-up. Provide solid backing and form supports to ensure stability of form liners.
 2. Form Material: Overlaid plywood in accordance with NIST PS 1. Provide B-B high density overlaid concrete form, Class I.
 3. Form Liners: Rigid PVC or fiberglass in pattern shown or indicated.
 4. Form Reuse: To be determined by ENGINEER at time of installation.
 5. Rustication Joints: Rigid PVC in profile shown or indicated.
 6. Panel Joints: Conceal joints behind rustication joints, unless approved by ENGINEER in writing.
- D. Form Ties:
1. Provide factory-fabricated metal form ties, designed to prevent form deflection, and to prevent spalling of concrete surfaces upon removal.
 2. Unless otherwise shown or indicated in the Contract Documents, provide ties so that portion of tie remaining within concrete after removal of exterior parts of tie is at least 1.5 inches from the outer concrete surface. Unless otherwise shown or indicated in the Contract Documents, provide form ties that will leave a hole no larger than one-inch diameter in concrete surface.
 3. Ties shall have waterstops on all exterior, below-grade walls, and walls subject to hydrostatic pressure.
 4. Ties shall leave a uniform, circular hole when forms are removed.
 5. Do not use removable ties unless accepted by ENGINEER. Removable ties are not allowed on exterior below-grade walls or walls subject to hydrostatic pressure. If removable ties are accepted, CONTRACTOR shall submit hole repair details for ENGINEER approval.
 6. Wire ties are not allowed.
 7. Do not use reinforcing bars shown by the Drawings as part of the form tie system unless approved by ENGINEER.
 8. Provide stainless steel form ties for areas with architectural finish. When used, tiebreak back point shall be at least one inch from outer concrete surface.
 9. Form ties assemblies and systems in liquid-containment structures shall be suitable for providing a liquid-tight structure and shall leave no metal or other material except concrete within 1-1/2 in. of the formed surface.
- E. Form Coatings:
1. Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede wetting of surfaces to be cured with water or curing compounds. For concrete surfaces that will be in contact with potable water or water that will be treated to become potable, form coating shall be a mineral oil base coating.
- F. Void-Forms:
1. Void (carton) forms shall be corrugated fiberboard used for creating a void space beneath grade beams and slabs on grade.
 2. Manufacturer: Provide void-forms by one of the following:
 - a. Savway Carton Forms
 - b. Sheplers

- c. SureVoid Products
- d. Or equal
- 3. Void-forms shall have moisture-resistant treated paper faces, be laminated with waterproof adhesive, and be biodegradeable. Void-forms shall have interior fabrication of uniform braced cellular configuration and shall be capable of sustaining minimum working load of 1,000 psf for minimum of ten days after concrete placement.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine substrate and conditions under which the Work will be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 FORM CONSTRUCTION

- A. Construct forms in accordance with ACI 347; to the exact sizes, shapes, lines, and dimensions shown; as required to obtain accurate alignment, location, and grades; to tolerances specified; and to obtain level and plumb work in finish structures. Provide for openings, offsets, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required. Use selected materials to obtain required finishes. Finish shall be in accordance with approved mock-up or sample panel, when specified.
- B. Allowable Tolerances:
 - 1. Construct forming to provide completed concrete surfaces complying with tolerances specified in ACI 117, ACI 301, and ACI 347.
 - a. Architectural finish forming, and where shown or indicated on the Drawings, shall be Class A surface, 1/8-inch offset.
 - b. Other surfaces exposed to view shall be Class B surface, 1/4-inch offset.
 - c. Other surfaces shall be Class C surface, 1/2-inch offset.
 - 2. Tolerances apply to form offsets and to irregularities within the formed surface when measured with a straightedge over a five-foot distance.
- C. Install forming and accessories for facilities in accordance with manufacturer's instructions, Laws and Regulations, and the Contract Documents.
- D. Fabricate forms for easy removal without damaging concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where the slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and assure ease of removal.
- E. Provide temporary openings where interior area of forming is inaccessible for cleanout, for inspection before concrete placement, and for placing concrete. Brace temporary closures and set tightly to forms to prevent loss of cement paste. Locate temporary openings on forms in locations as inconspicuous as possible, consistent with requirements of the Work. Form intersecting planes of openings to provide true, clean-cut corners, with edge grain of plywood not exposed as form for concrete.
- F. Falsework:
 - 1. Erect falsework and support, brace, and maintain falsework to safely support vertical, lateral, and asymmetrical loads applied until such loads can be supported by in-place concrete structures. Construct falsework so that adjustments can be made for take-up and settlement.

2. Provide wedges, jacks or camber strips to facilitate vertical adjustments. Carefully inspect falsework and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure; make necessary adjustments to produce finished Work of required dimensions.
- G. Forms for Smooth Finish Concrete:
1. Do not use metal cover plates for patching holes or defects in forms.
 2. Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections.
 3. Use extra studs, walers, and bracing to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Do not use narrow strips of form material that will produce bow.
 4. Assemble forms so they may be readily removed without damage to exposed concrete surfaces.
 5. Form molding shapes, recesses, rustication joints and projections with smooth-finish materials, and install in forms with sealed joints to prevent displacement.
- H. Corner Treatment:
1. Form exposed corners of beams, walls, foundations, bases and columns to produce smooth, solid, unbroken lines, except as otherwise shown or indicated in the Contract Documents. Chamfer exposed corners.
 2. Form chamfers with 3/4-inch by 3/4-inch strips, unless otherwise shown or indicated in the Contract Documents, accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Use rigid PVC chamfers for architecturally formed concrete.
 3. Extend terminal edges to required limit and miter chamfer strips at changes in direction.
 4. Reentrant or internal and unexposed corners may be formed either square or chamfered.
- I. Joints:
1. For joint treatment, comply with Section 03 15 00, Concrete Accessories. Locate joints as shown and specified.
- J. Openings and Built-In Work:
1. Provide openings in concrete forming shown or required under other Sections. Refer to Paragraph 1.1B of this Section for coordination requirements.
 2. Accurately place and securely support items to be built into forms.
- K. Sealing Forming:
1. Forming joints shall be tight-fitting or otherwise sealed to prevent loss of cement paste.
 2. Provide forming resting against concrete surfaces with compressible gasket material between the concrete and edge of form, to fill irregularities and create tight seal.
- L. Cleaning and Tightening:
1. Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before concrete is placed. Retighten forms immediately after placing concrete, as required to eliminate cement paste leaks.
- M. Tie Hole Repair:
1. Repair tie holes in accordance with Section 03 30 00, Cast-In-Place Concrete.
- 3.3 FORM COATINGS
- A. Coat form contact surfaces with non-staining form-coating compound before installing reinforcing materials. Do not allow excess form coating material to accumulate in forms or come into contact with surfaces that will be bonded to fresh concrete. Apply in compliance with manufacturer's instructions.

- B. Coat steel forms with non-staining, rust-preventative form oil, or otherwise protect against rusting. Do not use rust-stained steel forming.

3.4 INSTALLATION OF EMBEDDED ITEMS

- A. Set and build into forming anchorage devices and other embedded items, shown, specified, or required under other Sections. Refer to Paragraph 1.1B of this Section for coordination requirements. Use necessary setting drawings, diagrams, instructions, and directions.
- B. Edge Forms and Screeds Strips for Slabs:
 - 1. Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure units to support screeds.

3.5 VOID-FORMS

- A. Install void-forms where shown or indicated in the Contract Documents, to the thickness indicated, in accordance with manufacturer's recommendations.
- B. Where void-form is shown or indicated in the Contract Documents, place void-form to grades and elevations shown over an even, well-compacted subgrade to form continuous void space under entire extent of slab, mat, or grade beam.
- C. For structural slab applications, place 1/8-inch thick masonite or plywood sheet over void-form. Place void-forms in largest pieces practical and secure in place.
- D. Properly surround and void around upper portion of drilled piers at intersection of slab, grade beam or pier cap using premanufactured, non-field cut sealed void-form with curved, radial, vertical edge adjacent to drilled pier.
- E. Void-forms shall remain dry and undamaged prior to concrete placement. Replace damaged pieces prior to placing concrete. Seal all joints and exposed ends to prevent concrete leakage into void space.

3.6 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Before placing concrete, check ties, tie cones, tie waterstops, embedded items, form coatings, forming stability, alignment, and tolerances. Make corrections and adjustments to ensure forming complies with intent of the forming design, proper stability of forming systems, and accurate size and location of concrete members.
 - 2. During concrete placing, check forming and related supports to ensure that forms are not displaced and that completed Work will be within specified tolerances.
 - 3. If forms are unsatisfactory in any way, either before or during concrete placing, stop or postpone placing of concrete until defects are corrected as required by CONTRACTOR's or Supplier's professional engineer and accepted by ENGINEER.

3.7 REMOVAL OF FORMS

- A. Determination of time between placing concrete and removing forms is CONTRACTOR's responsibility. Requirements specified in this Section are minimum times and requirements intended to ensure that concrete will support its own weight, and do not consider additional effects of the construction. Additional effects of the construction shall be accounted for by CONTRACTOR when determining time for removing forming. Time for removing of forms is subject to ENGINEER's acceptance.

- B. Comply with requirements of ACI 301 and ACI 347, except as indicated in the Contract Documents.
- C. Removal of Forms for Walls, Columns, Sides of Beams and Girders, and Slab and Foundation Edges:
 1. Comply with requirements of the table below:

Table 03 11 00-A

Component	Average Daily Ambient Air Temperature (deg F)				Min. Concrete Compressive Strength for Form Removal
	Over 70 F	60 F to 70 F	50 F to 60 F	Below 50 F	
Walls	One day	Two days	Three days	See Paragraph 3.8.C.2 of this Section	750 psi
Columns	Two days	Three days	Four days		1000 psi
Side of beams and girders	One day	One day	Two days		500 psi
Slab and foundation edges	One day	One day	Two days		500 psi

2. When average daily ambient air temperature is below 50 degrees F, do not remove forms until concrete attains minimum compressive strength indicated in the table above for form removal, and comply with Paragraph 3.7.C.3.b of this Section.
 3. Concrete Strength Requirements for Form Removal:
 - a. For other than beams and elevated slabs, do not remove forms until concrete attains minimum concrete compressive strength indicated in Table 03 11 00-A for form removal.
 - b. For beams and elevated slabs, do not remove supporting forms or shoring until concrete attains minimum of 90 percent of its specified compressive strength.
- D. Alternative Criteria for Removing Forms for Walls, Columns, Sides of Beams and Girders, and Slab and Foundation Edges: CONTRACTOR has the option of submitting an alternative removal of forms table, together with supporting data, for ENGINEER's acceptance. Supporting data shall include representative field data for each different placement ambient temperature condition and minimum of three tests per temperature condition to ensure that accurate correlation between concrete strength and placement temperature is obtained.
 - E. Determination of In-place Concrete Strength:
 1. Determine compressive strength of in-place concrete by compression test specimens cured at the Site under the same conditions of temperature and moisture as the concrete member under consideration.
 2. Alternately, determine compressive strength of in-place concrete by maturity factor procedure in accordance with ASTM C1074 and approved by ENGINEER. Location of embedded thermistors or thermocouples shall be as approved by ENGINEER.
 - F. When high-early strength concrete is used, time for removing the forms will be developed at the Site from the age/strength relationships established for the materials and proportions used by tests in accordance with ACI 301.
 - G. Leave form facing material in place for minimum of four days after concrete placement, unless otherwise approved by ENGINEER.
 - H. Continue curing, including bottom surfaces of slabs and beams, after form removal in accordance with Section 03 30 00, Cast-In-Place Concrete.

3.8 PERMANENT SHORES

- A. Provide permanent shores in accordance with ACI 347.
- B. Reshores are not allowed.

3.9 REUSE OF FORMS

- A. Clean and repair surfaces of forms to be re-used in the construction. Do not use split, frayed, delaminated, or otherwise damaged form facing material. Apply form coating compound material to concrete contact surfaces as specified for forming.
- B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets. Do not use "patched" forms for exposed concrete surfaces. Form surfaces are subject to ENGINEER's approval.

END OF SECTION

SECTION 03 15 00 - CONCRETE ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete accessories.
- B. Related Sections:
 - 1. Section 03 11 00 - Concrete Forming.
 - 2. Section 03 60 00 - Grouting.
 - 3. Section 07 92 00 - Joint Sealants.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. ACI 301, Standard Specifications for Structural Concrete.
 - 2. ASTM D1752, Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
 - 3. CRD-C572, U.S. Army Corps of Engineers Specifications for Polyvinyl- Chloride Waterstop.

1.3 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Layout of construction and expansion joint locations. Submit and obtain approval prior to submitting concrete reinforcement Shop Drawings.
 - b. For construction and expansion joints that require waterstops, submit layout of locations showing waterstop details. Indicate waterstop type, waterstop joint conditions, and details on how joint conditions will be handled.
 - c. Layout of all control joint locations.
 - 2. Samples:
 - a. Submit Sample, at least six inches long each, of each type of waterstop proposed for use.
 - b. Submit Sample of foam rubber and cork expansion joint fillers.
 - c. Submit Sample of each type of prefabricated PVC waterstop joint.
- B. Informational Submittals: Submit the following:
 - 1. Manufacturer's Instructions: Manufacturer's specifications and installation instructions for all materials required.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Transportation and Handling of Products:
 - 1. Deliver materials to Site to ensure uninterrupted progress of the Work.
 - 2. Comply with Section 01 66 00, Product Storage and Handling Requirements.
- B. Storage and Protection:
 - 1. Store concrete joint materials on platforms or in enclosures or covered to prevent contact with ground and exposure to weather and direct sunlight. Comply with manufacturer's storage and protection requirements.
 - 2. Comply with Section 01 66 00, Product Storage and Handling Requirements.

PART 2 - PRODUCTS

2.1 WATERSTOPS

A. Polyvinyl Chloride (PVC):

1. Material Requirements:
 - a. Waterstops shall be extruded from elastomeric PVC compound containing plasticizers, resins, stabilizers, and other materials necessary to meet requirements of the Contract Documents and requirements of CRD-C572. Do not use reclaimed or scrap material.
 - b. Tensile strength of finished waterstop: 1,400 psi, minimum.
 - c. Ultimate elongation of finished waterstop: 280 percent, minimum.
 - d. Minimum thickness shall be 3/8-inch over entire width of waterstop.
 - e. Provide waterstops with minimum of seven ribs equally spaced at each end on each side. First rib shall be at the edge. Ribs shall be a minimum of 1/8-inch in height.
 - f. Provide waterstops with hog rings or factory-installed grommets anchored to exterior ribs to facilitate tying waterstop in position.
2. Split waterstops are not allowed.
3. Construction Joints: Waterstops shall be flatstrip ribbed type, six-inch minimum width, unless otherwise shown or indicated in the Contract Documents.
4. Expansion Joints: Waterstops shall be centerbulb ribbed type, nine-inch minimum width, unless otherwise shown or indicated in the Contract Documents. Centerbulb shall have minimum outside diameter of 7/8-inch.
5. Product and Manufacturer: Provide one of the following:
 - a. W.R. Meadows, Inc.
 - b. DCA Construction Products.
 - c. Greenstreak Plastic Products Company.
 - d. Paul Murphy Plastics Company.
 - e. Vinylex Corporation.
 - f. Or equal.

B. Hypalon:

1. Provide hypalon waterstops as shown or indicated in the Contract Documents, 40-mils thick.
2. Waterstop shall be an integral part of manufacturer's joint sealing system and shall be in accordance with manufacturer's published recommendations.
3. Product and Manufacturer: Provide one of the following:
 - a. Sikadur Combiflex, as manufactured by Sika Corporation.
 - b. Or equal.

C. Hydrophilic Waterstop Materials:

1. General Material Properties:
 - a. Bentonite-free, and expandable by minimum of 80 percent of dry volume in presence of water to form watertight joint seal without damaging concrete in which material is cast. Provide only where shown or indicated in the Contract Documents.
 - b. Material shall be composed of resins and polymers that absorb water and cause an increase in volume in completely reversible and repeatable process. Waterstop material shall be dimensionally stable after repeated wet-dry cycles with no deterioration of swelling potential.
 - c. Select materials that are recommended by manufacturer for type of liquid to be contained.
2. Hydrophilic Rubber Waterstop:
 - a. Minimum cross-sectional dimensions shall be 3/16-inch by 3/4-inch.
 - b. Product and Manufacturer: Provide one of the following:

- 1) Duroseal Gasket, by BBZ USA, Inc.
 - 2) Adeka Ultraseal MC-2010M, by Asahi Denka Kogyo K.K.
 - 3) Hydrotite, by Greenstreak Plastic Products Company.
 - 4) Or equal.
3. Hydrophilic Sealant:
- a. Hydrophilic sealant shall adhere firmly to concrete, metal, and PVC in dry or damp condition. When cured sealant shall be elastic indefinitely.
 - b. Product and Manufacturer: Provide one of the following:
 - 1) Duroseal Paste, by BBZ USA, Inc.
 - 2) Adeka Ultraseal P-201, by Asahi Denka Kogyo K.K.
 - 3) Hydrotite, by Greenstreak Plastic Products Company.
 - 4) SikaSwell S, by Sika Corporation.
 - 5) Or equal.

2.2 PREFORMED EXPANSION JOINT FILLER

- A. Provide preformed expansion joint filler complying with ASTM D1752, Type I (sponge rubber) or Type II (cork).

2.3 CONCRETE CONSTRUCTION JOINT ROUGHENER

- A. Provide water-soluble non-flammable, surface-retardant roughener.
- B. Product and Manufacturer: Provide one of the following for the types of joints specified:
 1. Rugasol-S, by Sika Corporation for horizontal joints only.
 2. Concrete Surface Retarder-Formula S, by Euclid Chemical Company, for horizontal joints only.
 3. Concrete Surface Retarder-Formula F, by Euclid Chemical Company, for vertical joints only.
 4. TK-6100 Concrete Form Surface Retarder, by TK Products.
 5. Or equal.

2.4 EPOXY BONDING AGENT

- A. Provide a two-component epoxy-resin bonding agent.
- B. Product and Manufacturer: Provide one of the following:
 1. Sikadur 32 Hi-Mod LPL, by Sika Corporation.
 2. Eucopoxy LPL, by the Euclid Chemical Company.
 3. Resi-Bond J-58, by Dayton Superior.
 4. Or equal.

2.5 EPOXY-CEMENT BONDING AGENT

- A. Provide three component epoxy resin-cement blended formulated as bonding agent.
- B. Product and Manufacturer: Provide one of the following:
 1. Sika Armatec 110 EpoCem, as manufactured by Sika Corporation.
 2. Duralprep A.C., as manufactured by the Euclid Chemical Company.
 3. Emaco P24, as manufactured by MBT/ChemRex.
 4. Or equal.

2.6 JOINT SEALANT AND ACCESSORIES

- A. For joint sealants and accessories used on isolation joints, control joints, and expansion joints, refer to Section 07 92 00, Joint Sealants.

2.7 CONCRETE BOND BREAKERS

- A. Provide asphalt-saturated rag felt building paper, not less in weight than commercially known as 15 pound felt building paper, which weighs 15 pounds per 100 square feet.
- B. Chemical Bond Breaker:
 - 1. Provide medium solids resin solution chemical concrete bond breaker complying with ASTM C309, Type I, Class B.

2.8 NEOPRENE BEARING PADS

- A. Product and Manufacturer: Provide one of the following:
 - 1. 65 Durometer, Sheet Neoprene No. 1200, as manufactured by Williams Products Company.
 - 2. Or equal.

2.9 RUBBER BONDING AGENT

- A. Product and Manufacturer: Provide one of the following:
 - 1. Scotch-Grip 1300 Rubber Adhesive, as manufactured by 3M Company.
 - 2. Or equal.

PART 3 - EXECUTION

3.1 INSPECTION

- A. CONTRACTOR and installing Subcontractor, if any, shall examine substrate and conditions under which the Work is to be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 CONSTRUCTION JOINTS

- A. Comply with requirements of ACI 301 and the Contract Documents.
- B. Locate and install construction joints as shown or indicated on the Drawings. Where not shown or indicated, locate joints to not impair strength of the structure; position joints at points of minimum shear. Location of joints shall be approved by ENGINEER. In addition to joints shown or indicated on the Drawings, locate construction joints as follows:
 - 1. In foundation mats, locate joints at spacing of approximately 40 feet. Joints shall be located within middle third of element span, unless otherwise shown or indicated on the Drawings. Element span shall be considered distance between piles or, as determined by ENGINEER, distance between bearing elements, such as columns, exterior walls and interior walls. Place concrete in strip pattern, unless otherwise shown or indicated on the Drawings.
 - 2. In walls, locate joints at a maximum spacing of 40 feet. Locate joints away from wall intersections a minimum of one-quarter of the clear span distance between wall intersections measured horizontally.
 - 3. In structural slabs and beams, joints shall be located within middle third of element span and shall be located in compliance with ACI 301, unless otherwise shown or indicated on the Drawings.
 - 4. In slabs on grade, locate joints at spacing of approximately 40 feet. Place concrete in strip pattern, unless otherwise shown or indicated on the Drawings.
- C. Horizontal Joints:

1. Roughen concrete at interface of construction joints by abrasive blasting, hydroblasting, or using surface retardants and water jets to expose aggregate and remove accumulated concrete on projecting rebar immediately subsequent to form stripping, unless otherwise approved by ENGINEER. Immediately before placing fresh concrete, thoroughly clean existing contact surface using stiff brush or other tools and stream of pressurized water. Surface shall be clean and wet, and free from pools of water at time of placing fresh concrete.
2. Remove laitance, waste mortar, and other substances that may prevent complete adhesion. Where joint roughening was performed more than seven days prior to concrete placing or where dirt or other bond reducing contaminants are on surface, perform additional light abrasive blasting or hydroblasting to remove laitance and all bond- reducing materials just prior to concrete placement.
3. Provide over contact surface of concrete a six-inch layer of Construction Joint Grout as specified in Section 03 60 00, Grouting. Place fresh concrete before grout has attained its initial set. Placement of grout may be omitted if concrete mix has slump increased to at least six inches by addition of high range water reducer.

D. Vertical Joints:

1. Apply roughener to the form in thin, even film by brush, spray, or roller in accordance with manufacturer's instructions. After roughener is dry, concrete may be placed.
2. When concrete has been placed, remove joint surface forms as early as necessary to allow for removal of surface retarded concrete. Forms covering member surfaces shall remain in place as required under Section 03 11 00, Concrete Forming. Wash loosened material off with high-pressure water spray to obtain roughened surface subject to approval by ENGINEER. Alternately, surface shall be roughened by abrasive blasting or hydroblasting to expose aggregate. Outer one inch of each side of joint face shall be masked and protected from blasting to avoid damaging member surface.

3.3 EXPANSION JOINTS

- A. Comply with requirements of ACI 301 and this Section.
- B. Locate and install expansion joints as shown and indicated in the Contract Documents. Install joint filler in accordance with manufacturer's instructions. Install sealants as specified in this Section.

3.4 CONTROL JOINTS

- A. Provide control joints in non-water bearing slabs on grade as shown or indicated on the Drawings. Where control joints are not shown or indicated on the Drawings, space control joints at 24 to 36 times thickness of slab in both directions. Locate control joints only at places approved by ENGINEER.
- B. A groove, with depth of at least 25 percent of the member thickness, shall be tooled, formed, or saw-cut in concrete. Groove shall be filled with joint sealant material in accordance with Section 07 92 00, Joint Sealants.
- C. Where control joint is formed by sawcutting, make sawcut in presence of ENGINEER immediately after concrete has set sufficiently to support the saw and be cut without damage to concrete. Keep concrete continually moist during cutting. Joints shall be approximately 1/8-inch wide.
- D. Control joints may be formed with tool or by inserting joint forming strip. After concrete has achieved design strength, remove upper portion of joint forming strip and fill void with sealant.

3.5 ISOLATION JOINTS

- A. Provide isolation joint where sidewalk or other slab on grade abuts a concrete structure and slab on grade is not shown doweled into that structure. Form isolation joint by 1/2-inch joint filler with upper 1/2-inch of joint filled with sealant.

3.6 WATERSTOPS

A. General:

1. Comply with ACI 301 and this Section. Make joints in accordance with manufacturer's instructions.
2. Provide PVC waterstops, except where otherwise shown or indicated on the Drawings.
3. Provide waterstops in all joints where concrete construction is below grade or intended to retain liquid. Install waterstop to the higher of: at least 12 inches above grade, or 12 inches above overflow liquid level in tanks.
4. Waterstops shall be fully continuous for extent of joint and with waterstops in intersecting joints. Maintain waterstop continuity at transitions between waterstops in joints at different levels and orientations.
5. In vertical joints in walls that are free at the top, waterstops shall extend no closer than six inches from top of wall.
6. In placing concrete around horizontal waterstops, with waterstop flat face in horizontal plane, work the concrete under waterstops by hand to avoid forming air and rock pockets.

B. Polyvinyl Chloride Waterstop:

1. Waterstops shall be positively held from displacement during concrete placing. Tie waterstops to reinforcement or other rigid supports at maximum spacing of 18 inches so that waterstop is securely and rigidly supported in proper position during concrete placing. Continuously inspect waterstops during concrete placing to ensure proper positioning.
2. Perform splicing in waterstops by heat sealing adjacent waterstop sections in accordance with manufacturer's printed recommendations. The following is required:
 - a. Material shall not be damaged by heat sealing.
 - b. Splices shall have tensile strength of not less than 60 percent of unspliced material's tensile strength.
 - c. Maintain the continuity of waterstop ribs and of its tubular center axis.
3. Only butt-type joints of ends of two identical waterstop sections shall be made while material is in forms.
4. Prefabricated PVC Waterstop Joint:
 - a. Joints with waterstops involving more than two ends to be jointed together, and joints that involve an angle cut, alignment change, or joining of two dissimilar waterstop sections, shall be prefabricated by CONTRACTOR or manufacturer prior to placing in the forms.
 - b. Prefabricated joints shall have minimum of 2.0 feet of waterstop material beyond joint in each direction.
 - c. Install prefabricated joint assembly in the forms and butt-weld each two-foot end to a straight-run portion of waterstop in place in the forms.
5. Where centerbulb waterstop intersects and is jointed with non-centerbulb waterstop, seal end of centerbulb using additional PVC material as required.
6. Symmetrical halves of waterstops shall be equally divided between concrete placements at joints and centered within joint width, unless shown or indicated otherwise in the Contract Documents. Place centerbulb waterstops in expansion joints so that centerbulb is centered on joint filler material.
7. When waterstop is installed in the forms or embedded in first concrete placement and waterstop remains exposed to atmosphere for more than four days, implement suitable precautions to shade and protect exposed waterstop from direct rays of sun during entire exposure, until exposed portion of waterstop is embedded in concrete.

8. Protect waterstop placed in joints intended for future concrete placement from direct rays of the sun by temporary means until permanent cover is installed, so that waterstop is not exposed to direct rays of the sun for more than four days total.

C. Hypalon Waterstop:

1. Provide hypalon waterstop where shown or indicated on the Drawings.
2. Install in accordance with manufacturer's recommendations.

D. Hydrophilic Rubber Waterstop and Sealant:

1. Where a hydrophilic rubber waterstop or sealant is required in accordance with the Contract Documents, or where approved by ENGINEER, install waterstop or sealant in accordance with manufacturer's instructions and recommendations; except, as modified in the Contract Documents.
2. When requested by ENGINEER, provide manufacturer's technical assistance at the Site.
3. Locate waterstop or sealant as near as possible to center of joint. Waterstop or sealant shall be continuous around entire joint. Minimum distance from edge of waterstop to face of the member shall be three inches.
4. Where hydrophilic rubber waterstop is used in combination with PVC waterstop, hydrophilic rubber waterstop shall overlap PVC waterstop for minimum of six inches. Fill contact surface between hydrophilic rubber waterstop and PVC waterstop with hydrophilic sealant.
5. Where wet curing methods are used, apply hydrophilic rubber waterstop and sealant after curing water is removed and just prior to closing up of the forms for concrete placement. Protect hydrophilic rubber waterstop and sealant from direct rays of sun and from becoming wet prior to concrete placement. If material becomes wet and expands, allow material to dry until material has returned to original cross-sectional dimensions before placing concrete.
6. Install hydrophilic rubber waterstop in bed of hydrophilic sealant, before skinning and curing begins, so that irregularities in concrete surface are completely filled and waterstop is bonded to sealant. After sealant has cured, install concrete nails, with washers of a diameter equal to waterstop width, to secure waterstop to concrete at maximum spacing of 1.5 feet.
7. Prior to installing hydrophilic sealant, wire brush or sandblast the concrete surface to remove laitance and other materials that may interfere with bonding. Metal and PVC surfaces to receive sealant shall be cleaned of paint and any material that may interfere with bond. When sealant alone is shown or indicated in the Contract Documents, place sealant placed in built-up bead which has a triangular cross section with each side of triangle at least 3/4-inch long, unless otherwise indicated in the Contract Documents. Do not place concrete until sealant has cured as recommended by sealant manufacturer.

3.7 BONDING AGENT

- A. Use epoxy bonding agent for bonding of fresh concrete to concrete that has been in place for at least 60 days, and for bonding to existing concrete.
- B. Use epoxy-cement bonding agent for the following:
 1. Bonding toppings and concrete fill to concrete that has been in place for at least 60 days, and for bonding to existing concrete.
 2. For locations where bonding agent is required, and concrete cannot be placed within open time period of epoxy bonding agent.
- C. Use cement-water slurry as bonding agent for toppings and concrete fill to new concrete. Cement water slurry shall be worked into surface with stiff bristle broom and place the concrete before cement-water slurry dries.

- D. Handle and store bonding agent in accordance with manufacturer's printed instructions and safety precautions.
- E. Mix bonding agent in accordance with manufacturer's instructions.
- F. Before placing fresh concrete, thoroughly roughen and clean hardened concrete surfaces and coat with bonding agent not less than 1/16-inch thick. Place fresh concrete while bonding agent is still tacky (within its open time), without removing in-place bonding agent coat, and as directed by manufacturer.

3.8 BEARING PAD INSTALLATION

- A. Neoprene Bearing Pad: Install with water insensitive adhesive in accordance with manufacturer's instructions.

END OF SECTION

SECTION 03 21 00 – REINFORCING STEEL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Furnish and place reinforcement of the type, size, and details shown on the plans.
- B. Related Specification Sections include, but are not necessarily limited to:
 - 1. Division 00 – Bidding Requirements, Contract Forms and Conditions of the Contract
 - 2. Division 01 – General Requirements

1.2 PRICE AND PAYMENT PROCEDURES

- A. Reinforcing Steel
 - 1. Measurement
 - a. This Item is considered subsidiary to the structure or Items being placed.
 - 2. Payment
 - a. The work performed and the materials furnished in accordance with this Item are subsidiary to the structure or Items being placed and no other compensation will be allowed.

1.3 REFERENCES

- A. Reference Standards
 - 1. Reference standards cited in this Specification refer to the current reference standard published at the time of the latest revision date logged at the end of this Specification, unless a date is specifically cited.
 - 2. American Concrete Institute (ACI):
 - a. 301, Specification for Structural concrete for Buildings
 - b. 315, Manual of Standard Practice for Detailing Reinforced Concrete Structures.
 - c. 318, Building Code Requirements for Structural Concrete.
 - d. 350, Code Requirements for Environmental Engineering Concrete Structures.
 - e. SP66, Detailing Manual.
 - f. 117, Specification for Tolerances for Concrete Construction and Materials.
 - 1) ASTM International (ASTM):
 - g. A1064/A1064M Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
 - h. A184/A184M, Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement.
 - i. A615A615M Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
 - j. A706/A706M Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
 - k. A775/A775M Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
 - l. A955/A955M Plain and Deformed Stainless-Steel Bars for Concrete Reinforcement.
 - m. A767/A767M Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
 - 1) American Welding Society (AWS).
 - n. D1.1, Structural Welding Code - Steel.
 - o. D1.4, Structural Welding Code - Reinforcing Steel.
 - 1) Concrete Reinforcing Steel Institute (CRSI)
 - p. Manual of Standard Practice.
 - q. RB4.1, Supports for Reinforcement Used in Concrete.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Work Included
 - 1. Furnish labor and reinforcing materials required to cut, bend, tie, splice, place and support the reinforcement in the material grades, sizes, quantities and locations specified.
 - 2. The Work includes fabrication and placement of reinforcement including bars, ties and supports, and welded wire fabric for concrete, encasements and fireproofing.

1.5 SUBMITTALS

- A. Submittals shall be in accordance with Section 01 33 00.
- B. All submittals shall be approved by the Engineer prior to delivery and/or fabrication.

1.6 ACTION SUBMITTALS/INFORMATIONAL SUBMITTALS

- A. Shop Drawings: Submit for approval the following:
 - 1. Manufacturer's specifications and installation instructions for all materials and reinforcement accessories.
 - 2. Drawings for fabrication, bending, and placement of concrete reinforcement. Comply with ACI 315, Parts A and B. For walls, show elevations of each wall to depict reinforcing. For slabs, show top and bottom reinforcing on separate plan views. Show bar schedules, stirrup spacing, diagrams of bent bars, arrangements and assemblies, as required for the fabrication and placement of concrete reinforcement unless otherwise noted. Splices shall be kept to a minimum. Splices in regions of maximum tension stresses shall be avoided whenever possible.
 - 3. Drawings detailing the location of all construction, contraction and expansion joints shall be submitted and approved before Shop Drawings for reinforcing steel are submitted. Reinforcing submittals not showing jointing will be rejected.
- B. Certificates:
 - 1. Submit one copy of steel producer's certificates of mill analysis, tensile and bend tests for reinforcing steel.
- C. Adhesive for Drilled Dowels:
 - 1. Product Data:
 - a. Manufacturer's catalog information.
 - b. Manufacturer's instructions for preparation, placement, drilling of holes, installation, and handling of cartridges, nozzles and equipment.
 - c. Contact for manufacturer including name, telephone number, and address.
 - d. Manufacturer's Certificate of Proper Installation
 - e. Manufacturer's written letter of certification identifying installer's qualifications to install the product.
 - f. Doweling system ICC-ES Reports.
 - g. Detailed step-by-step instructions for the Special Inspection procedure in accordance with ICC-ES Reports and IBC.

1.7 QUALITY ASSURANCE

- A. TOLERANCES: Reinforcement shall be placed where specified, with the tolerances in ACI 117.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement

- B. Store steel reinforcement above the surface of the ground upon platform skids or other supports. Protect from mechanical and chemical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, steel reinforcement shall be free from dirt, scale, dust, rust, paint, oil and other foreign material. Tagging shall be associated with approved reinforcing steel submittal drawings.

PART 2 - PRODUCTS

2.1 PRODUCT TYPES AND MATERIALS

- A. Reinforcing Bars: ASTM A615, or A706 and as follows:
 - 1. Provide Grade 60 for all bars, unless indicated otherwise.
- B. Mechanical Couplers
 - 1. Where permitted in writing by the Engineer, mechanical couplers may be used. Unless otherwise specified, splicing devices shall be a full mechanical connection which shall develop in tension or compression, as required, at least 125 percent of specified yield strength (fy) of the bar. Where a Type 2 splice is specified, the splicing device shall develop at least the greater of specified tensile capacity or 125% of specified yield capacity of the bars being spliced. Submit manufacturer ICC-ES, IAMPO-UES, or other testing agency report of compliance.
 - 2. Mechanical threaded couplers shall be one of the following, or approved equal:
 - a. Lenton Taper Threaded Rebar Couplers by Erico, Inc.
 - b. Lenton Form Saver Couplers by Erico, Inc.
 - c. Cadweld Rebar Coupler by Erico, Inc.
- C. Steel Wire: ASTM A 82.
- D. Welded Smooth Wire Fabric: ASTM A1064/A1064M.
 - 1. Furnish in flat sheets, not rolls.
- E. Supports for Reinforcement: Bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcement in place.
 - 1. Use wire bar type supports complying with CRSI RB4.1, except as otherwise specified below. Do not use unacceptable materials such as wood or brick.
- F. Drilled Dowels
 - 1. Adhesive material for drilled dowels shall be a two-part epoxy adhesive. The resin shall be a high modulus, moisture insensitive type. The adhesive shall be packaged in a cartridge type dispensing system with a mixing nozzle. The adhesive shall be formulated to maintain its bond and integrity under continuous submergence by water. The adhesive anchoring systems shall have an ultimate capacity in excess of 125 percent of the yield strength of the reinforcing steel at an embedment of 12 bar diameters, and shall be confirmed by a pull test at the project site.
 - 2. Adhesive systems shall be:
 - a. HIT RE 500 SD, manufactured by Hilti Corporation.
 - b. No substitutes will be considered.

2.2 FABRICATION

- A. General: Fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with CRSI, "Manual of Standard Practice". In case of fabricating errors, do not re-bend or straighten reinforcement.

- B. Unacceptable Materials: Reinforcement with any of the following defects will not be permitted in the Work:
 - 1. Bar lengths, bends, and other dimensions exceeding specified fabrication tolerances.
 - 2. Bends or kinks not shown on approved Shop Drawings.
 - 3. Bars with reduced cross-section due to excessive rusting or other cause, as determined by CRSI CTN M-2-11, to verify compliance with the relevant ASTM specification.
 - 4. Bars that have been field modified or cut without written approval by the Engineer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Engineer shall examine the substrate and the conditions under which concrete reinforcement is to be placed, and notify Contractor, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to Engineer.
- B. Bars with excessive rust, debris, or other defect shall be removed and replaced where directed by the Engineer. Evaluation of rust can be evaluated using CRSI CTN M-2-11, to verify compliance with the relevant ASTM material specification.

3.2 PREPARATION

- A. Before any concrete is placed, all mortar blocks to be used for holding steel in position adjacent to formed surfaces shall be cast in individual molds, after which time the blocks shall be immersed in water for the remainder of at least a 4-day curing period. The blocks shall be cast with the sides beveled and in such a manner that the size of the block increases away from the surface to be placed against the forms. Blocks shall be in the form of a frustum of a cone or pyramid. Suitable tie wires shall be provided in each block for anchoring the block to the reinforcing steel, and to avoid displacement when placing the concrete. The size of the surface to be placed adjacent to the forms shall not exceed 2-1/2" square or the equivalent thereof when circular or rectangular areas are provided. Blocks shall be accurately cast to the thickness required, and the surface to be placed adjacent to the forms shall be a true plane free of surface imperfections.

3.3 INSTALLATION

- A. Comply with the applicable recommendations of specified codes and standards, and CRSI, "Manual of Standard Practice", for details and methods of reinforcement placement and supports.
- B. Clean reinforcement to remove loose rust and mill scale, earth, ice, and other foreign materials which reduce or destroy bond with concrete. Repair any visible holidays in epoxy coated reinforcing and coat ends of cut reinforcement.
- C. Placement
 - 1. Place steel reinforcement, as indicated on the plans with the specified tolerances. Hold securely in place during the concrete placement. The minimum clear distance between bars shall be per according to the concrete documents. Always pass vertical stirrups around the main tension members and securely attach thereto. Wire reinforcing together at a intersections to produce a sound mat or cage of reinforcement that will maintain the reinforcement in correct positions when the concrete is placed.
 - 2. Hold the reinforcing steel in concrete slabs firmly in place with wire supports or "chairs". Sizing and spacing of the chairs shall be in accordance with CRSI RB4.1.
 - 3. Space the reinforcing steel in concrete walls the proper distance from the face of the forms, as indicated on the drawings:
 - a. For finished wall surfaces exposed to view, use chairs.
 - b. For finished wall surfaces not exposed to view, use chairs or precast mortar blocks.

4. Where reinforcing conflicts with location of anchor bolts, inserts, etc., submit written notice to the Engineer so that revisions can be made before concrete is placed. No cutting of reinforcing shall be permitted without the written approval of the Engineer.
 5. Place welded wire fabric flat in longest practical lengths. Lap sheets of wire reinforcement according to the Contract Documents. Do not locate end laps over beams of continuous structures or midway between supporting beams. Offset end laps of adjacent widths to prevent continuous lap. Fasten ends and sides of welded wire fabric at 48" o.c. with tie wire.
 6. Reinforcement shall extend through construction joints.
 7. Welded wire reinforcement shall be placed and supported to comply with the tolerances specified in Contract Documents .
- D. Position, support, and secure reinforcement against displacement during formwork construction or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers and hangers, as required.
1. Place reinforcement to obtain the minimum concrete coverages as shown and as specified in ACI 350. Arrange, space, and securely tie bars and bar supports together with 16 gauge wire to hold reinforcement accurately in position during concrete placement operations. Set wire ties so that twisted ends are directed away from exposed concrete surfaces.
 2. Prior to placement of concrete, Contractor shall demonstrate to Engineer that the specified cover of reinforcement has been attained by survey.
 3. Reinforcing steel shall not be secured to forms with wire, nails or other ferrous metal. Metal supports subject to corrosion shall not touch formed or exposed concrete surfaces.
 4. Adjusting the location of reinforcing during concrete placement is not permitted, except when wire mesh adjustments occur during concrete placement. Reinforcing must be firmly secured at specified locations prior to concrete placement.
- E. Install welded wire fabric in as long lengths as practical. Lap adjoining pieces at least one full mesh and lace splices with 16-gage 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.
- F. Provide sufficient numbers of supports of strength required to carry reinforcement. Do not place reinforcing bars more than 2-inches beyond the last leg of any continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.
- G. Lap Splices:
1. Provide a lap table to show standard reinforcement splices including lapping ends, placing bars in contact, and tying tightly with wire. Where spliced bars are not in direct contact, spacing shall not exceed that specified in the Drawings. Comply with requirements shown on the Drawings for minimum lap of spliced bars.
- H. Mechanical Couplers:
1. Mechanical butt splices shall be in accordance with the recommendation of the manufacturer of the mechanical splicing device. Butt splices shall develop 125 percent of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Bars shall be flame dried before butt splicing. Adequate jigs and clamps or other devices shall be provided to support, align, and hold the longitudinal centerline of the bars to be butt spliced in a straight line. Couplers shall be used only when permitted in writing by the Engineer.
- I. Welded Splices
1. Only Exothermic-welded splicing of reinforcing is permitted. Welding of crossing bars (tack welding) for assembly of reinforcement is prohibited.

J. Drilled Dowels

1. Drilled dowels shall be reinforcing dowels set in a resin adhesive in a hole drilled into hardened concrete.
2. Holes shall be drilled to the adhesive anchor system manufacturer's recommended diameter and depth to develop the required pullout resistance but shall not be greater in diameter than 1/4-inch more than the nominal bar diameter nor less than 12 times the nominal bar diameter in depth unless specified otherwise in the Drawings.
3. The hole shall be drilled by methods which do not interfere with the proper bonding of the resin. Only masonry type drill bits shall be used.
4. Existing reinforcing steel in the vicinity of proposed holes shall be located prior to drilling. The location of holes to be drilled shall be adjusted to avoid drilling through existing reinforcing bars.
5. The hole shall be brushed (non-metallic bristle brush only) and blown clean with clean, dry compressed air to remove all dust and loose particles.
6. Resin shall be injected into the hole through the injection system-mixing nozzle (and any necessary extension tubes) placed to the bottom of the hole. The discharge end shall be withdrawn as resin is placed but kept immersed to prevent formation of air pockets. The hole shall be filled to a depth that ensures that excess material is expelled from the hole during dowel placement.
7. Dowels shall be twisted during insertion into the partially filled hole so as to guarantee full wetting of the bar surface with resin. The bar shall be inserted slowly enough to avoid developing air pockets.

3.4 FIELD QUALITY CONTROL

- A. Concrete shall not be placed until the reinforcing steel is inspected and written permission for placing concrete is granted by the Engineer. All concrete placed in violation of this provision will be rejected. The Contractor shall give 24-hour written notice to the Owner's representative prior to reinforcing steel inspection.
- B. Formwork for walls and other vertical members will not be closed up until the reinforcing steel is inspected and written permission for placing concrete is granted by the Engineer. All concrete placed in violation of this provision will be rejected.
- C. Testing of Drilled Dowels: The Owner shall employ a testing agency to perform field quality control testing of the drilled dowel installation. After completion of the manufacturer's recommended curing period and prior to placement of connecting reinforcing, ten percent of drilled dowels installed shall be proof tested for pullout. The drilled dowels shall be tensioned to 60 percent of the specified yield strength. Where dowels are located less than six bar diameters from the edge of concrete, the Engineer will determine the tensile load required for the test. If any dowels fail, all installed dowels shall be tested. Dowels that fail shall be reinstalled and retested at Contractor's expense.

END OF SECTION

SECTION 03 30 00 – CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Cast-in place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures and finishes, for the following:
 - a. Piers
 - b. Footings
 - c. Slabs-on-grade
 - d. Foundation walls
 - e. Retaining walls (non TxDOT)
 - f. Suspended slabs
 - g. Blocking
 - h. Cast-in-place manholes
 - i. Concrete vaults for meters and valves
 - j. Concrete encasement of utility lines
- B. Deviations from these Trinity River Authority of Texas Guidelines
 - 1. None.
- C. Related Specification Sections include, but are not necessarily limited to:
 - 1. Division 00 – Procurement and Contracting Requirements
 - 2. Division 01 – General Requirements

1.2 PRICE AND PAYMENT PROCEDURES

- A. Cast-in-Place Concrete
 - 1. Measurement
 - a. This Item is considered subsidiary to the structure or Items being placed.
 - 2. Payment
 - a. The work performed and the materials furnished in accordance with this Item are subsidiary to the structure or Items being placed and no other compensation will be allowed.

1.3 REFERENCES

- A. Definitions
 - 1. Cementitious Materials
 - a. Portland cement alone or in combination with 1 or more of the following:
 - 1) Blended hydraulic cement
 - 2) Fly ash
 - 3) Other pozzolans
 - 4) Ground granulated blast-furnace slag
 - 5) Silica fume
 - 2. Subject to compliance with the requirements of this specification
- B. Reference Standards
 - 1. Reference standards cited in this Specification refer to the current reference standard published at the time of the latest revision date logged at the end of this Specification, unless a date is specifically cited.
 - 2. American Association of State Highway and Transportation (AASHTO):
 - a. M182, Burlap Cloth Made from Jute or Kenaf.

3. American Concrete Institute (ACI):
 - a. ACI 117 Specification for Tolerances for Concrete Construction and Materials
 - b. ACI 301 Specifications for Structural Concrete
 - c. ACI 305.1 Specification for Hot Weather Concreting
 - d. ACI 306.1 Standard Specification for Cold Weather Concreting
 - e. ACI 308.1 Standard Specification for Curing Concrete
 - f. ACI 318 Building Code Requirements for Structural Concrete
 - g. ACI 347 Guide to Formwork for Concrete
 - h. ACI 350 Code Requirements for Environmental Engineering Concrete Structures
4. American Institute of Steel Construction (AISC):
 - a. 303, Code of Standard Practice for Steel Buildings and Bridges.
5. ASTM International (ASTM):
 - a. A36, Standard Specification for Carbon Structural Steel.
 - b. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - c. A193, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications.
 - d. A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - e. A706, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - f. C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - g. C33, Standard Specification for Concrete Aggregates.
 - h. C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - i. C42, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
 - j. C94, Standard Specification for Ready-Mixed Concrete.
 - k. C109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or {50-milimeter} Cube Specimens)
 - l. C143, Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - m. C171, Standard Specification for Sheet Materials for Curing Concrete.
 - n. C150, Standard Specification for Portland Cement.
 - o. C172, Standard Practice for Sampling Freshly Mixed Concrete.
 - p. C219, Standard Terminology Relating to Hydraulic Cement.
 - q. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
 - r. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
 - s. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - t. C494, Standard Specification for Chemical Admixtures for Concrete.
 - u. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
 - v. C881, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - w. C989, Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.
 - x. C1017, Standard Specifications for Chemical Admixtures for Use in Producing Flowing Concrete.
 - y. C1059, Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.
 - z. C1064, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
 - aa. C1240, Standard Specification for Silica Fume Used in Cementitious Mixtures.
 - bb. E1155, Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers.
 - cc. F436, Standard Specification for Hardened Steel Washers.

6. American Welding Society (AWS).
 - a. D1.1, Structural Welding Code - Steel.
 - b. D1.4, Structural Welding Code - Reinforcing Steel.
7. Concrete Reinforcing Steel Institute (CRSI)
 - a. Manual of Standard Practice
8. Texas Department of Transportation
 - a. Standard Specification for Construction and Maintenance of Highways, Streets and Bridges

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Work Included
 1. Design, fabrication, erection and stripping of formwork for cast in place concrete including shoring, reshoring, falsework, bracing, proprietary forming systems, prefabricated forms, void forms, permanent metal forms, bulkheads, keys, blockouts, sleeves, pockets and accessories.
 - a. Erection shall include installation in formwork of items furnished by other trades.
 2. Furnish all labor and materials required to fabricate, deliver and install reinforcement and embedded metal assemblies for cast in place concrete, including steel bars, welded steel wire fabric, ties, supports and sleeves.
 3. Furnish all labor and materials required to perform the following:
 - a. Cast-in-place concrete
 - b. Concrete mix designs
 - c. Grouting

1.5 SUBMITTALS

- A. Submittals shall be in accordance with Section 01 33 00, SUBMITTALS and shall include:
 1. Shop Drawings:
 - a. Mix design: For each concrete mix, complete the form "Concrete Mix Design" and one of the following forms: "Documentation of Required Average Strength – Field Strength Test Record" or "Documentation of Average Strength – Trial Mixtures".
 - b. Submit a schedule to the Owner's representative which shows the sequence of concrete placements.
 2. Certified Test Reports:
 - a. Materials used in the trial mix design.
 - b. Aggregate, conforming to ASTM C33, including the test reports for soundness and abrasion resistance.
 - c. Aggregate:
 - 1) Verification that aggregate is not "potentially reactive" per ASTM C289.
 - 2) Or a cement chemical analysis indicating that the total alkali content is acceptable per section 2.02-A.
 - d. Seven (7) day and 28-day compressive strength tests results.
 - 1) When more than fifteen (15) 28-day compressive tests results are available from the current project for a given class of concrete, include the 15 test running average compressive strength versus the required average compressive strength (based on the previous 15 tests) in graphical form.
 3. Record Data: Manufacturer's literature on specified materials

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications
 1. A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94 requirements for production facilities and equipment
 2. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities"

- B. Source Limitations
 - 1. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from 1 source and obtain admixtures through 1 source from a single manufacturer.
- C. ACI Publications
 - 1. Comply with the following unless modified by requirements in the Contract Documents:
 - a. ACI 301 Sections 1 through 5
 - b. ACI 117
- D. Concrete Testing Service
 - 1. Engage a qualified independent testing agency to perform material evaluation tests for material submittals.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement
 - 1. Deliver, store, and handle steel reinforcement to prevent bending and damage.
 - 2. Avoid damaging coatings on steel reinforcement.
- B. Waterstops
 - 1. Store waterstops under cover to protect from moisture, sunlight, dirt, oil and other contaminants.

PART 2 - PRODUCTS

2.1 PRODUCT TYPES AND MATERIALS

- A. Manufacturers
 - 1. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - a. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
 - b. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
- B. Form-Facing Materials
 - 1. Rough-Formed Finished Concrete
 - a. Plywood, lumber, metal or another approved material
 - b. Provide lumber dressed on at least 2 edges and 1 side for tight fit.
 - 2. Chamfer Strips
 - a. Wood, metal, PVC or rubber strips
 - b. 3/4-inch x 3/4-inch, minimum
 - 3. Rustication Strips
 - a. Wood, metal, PVC or rubber strips
 - b. Kerfed for ease of form removal
 - 4. Form-Release Agent
 - a. Commercially formulated form-release agent that will not bond with, stain or adversely affect concrete surfaces
 - b. Shall not impair subsequent treatments of concrete surfaces
 - c. For steel form-facing materials, formulate with rust inhibitor.
 - 5. Form Ties

- a. Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
 - b. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.
 - c. Furnish ties that, when removed, will leave holes no larger than 1 inch in diameter in concrete surface.
 - d. Furnish ties with integral water-barrier plates to walls indicated to receive damp-proofing or waterproofing.
- C. Steel Reinforcement
- 1. Reinforcing Bars
 - a. As specified in 03 21 00 – Reinforcing Steel.
- D. Reinforcement Accessories
- 1. Smooth Dowel Bars
 - a. ASTM A615, Grade 60, steel bars (smooth)
 - b. Cut bars true to length with ends square and free of burrs.
 - 2. Bar Supports
 - a. Bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire reinforcement in place
 - b. Manufacture bar supports from steel wire, plastic or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 - 1) For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
 - 2) For slabs-on-grade, provide sand plates, horizontal runners or precast concrete blocks on bottom where base material will not support chair legs or where vapor barrier has been specified.
 - 3) No natural materials will be allowed for reinforcement support
- E. Embedded Metal Assemblies
- 1. Steel Shapes and Plates: ASTM A36
 - 2. Headed Studs: Heads welded by full-fusion process, as furnished by TRW Nelson Stud Welding Division [ENGINEER: CONFIRM APPROVED STUDS ALLOWED] or approved equal
- F. Adhesive Anchors and Dowels
- 1. Adhesive anchors shall consist of threaded rods anchored with an adhesive system into hardened concrete or grout-filled masonry.
 - a. The adhesive system shall use a 2-component adhesive mix and shall be injected with a static mixing nozzle following manufacturer's instructions.
 - b. The embedment depth of the rod shall provide a minimum allowable bond strength that is equal to the allowable yield capacity of the rod, unless otherwise specified.
 - 2. Available Products
 - a. Hilti HIT HY 200
 - b. Threaded Rods: ASTM A193 Grade B8M Type 316 stainless steel
 - c. Nuts: ASTM A193 Grade B8M Type 316 stainless steel.
 - d. Washers: Type 316 stainless steel
- G. Inserts
- 1. Provide metal inserts required for anchorage of materials or equipment to concrete construction where not supplied by other trades:

- a. In vertical concrete surfaces for transfer of direct shear loads only, provide adjustable wedge inserts of Type 316 stainless steel, complete with bolts, nuts and washers.
 - 1) Provide ¾-inch bolt size, unless otherwise indicated.
- b. In horizontal concrete surfaces and whenever inserts are subject to tension forces, provide threaded inserts of malleable cast iron furnished with full depth bolts.
 - 1) Provide ¾-inch bolt size, unless otherwise indicated.

H. Concrete Materials

1. Cementitious Material

- a. Use the following cementitious materials, of the same type, brand, and source, throughout Project:
 - 1) Portland Cement
 - a) ASTM C150, Type I/II, gray
 - b) Supplement with the following:
 - (1) Fly Ash
 - (a) ASTM C618, Class C or F
 - (2) Ground Granulated Blast-Furnace Slag
 - (b) ASTM C989, Grade 100 or 120.
 - 2) Normal-Weight Aggregates
 - a) ASTM C33, Class 3S coarse aggregate or better, graded
 - b) Provide aggregates from a single source.
 - 3) Maximum Coarse-Aggregate Size
 - a) ¾-inch nominal
 - 4) Fine Aggregate
 - a) Free of materials with deleterious reactivity to alkali in cement
 - 5) Water
 - a) ASTM C94 and potable

I. Admixtures

1. Air-Entraining Admixture

- a. ASTM C260
 - 1) The total average air content shall be in accordance with recommendations of ACI 211.1; 4.5% ±1.5% for 1 1/2" maximum size aggregate.
- b. Chemical Admixtures
 - 1) Air Entraining Admixture: Conforming to ASTM C260. The total average air content shall be in accordance with recommendations of ACI 211.1; 4.5% ±1.5% for 1 1/2" maximum size aggregate.
 - 2) Water Reducing Admixtures: Conforming to ASTM C494; Types "A" or "D" only; accurately measured and added to the mix according to the manufacturer's recommendations.
 - 3) Set Retarding Admixtures: Conforming to ASTM C494; Types "B" and "D" only; accurately measured and added to the mix in accordance to the manufacturer's recommendations.
 - 4) Water Reducing Admixtures - High Range (HRWR): High Range Water Reducer shall comply with ASTM C494, Type F or G. HRWR shall be accurately measured in accordance with the manufacturer's recommendations. HRWR shall be added to the concrete mix at the concrete batch plant. HRWR may not be added at placement site except to redose a batch and only after approval of the HRWR manufacturer. The high range water reducing admixture shall be able to maintain the plasticity range without significant loss of slump or rise in concrete temperature for 2 hours. With the use of these admixtures, slump limit shall be between 7" and 9" unless otherwise authorized by the manufacturer. Other admixtures may only be used with the HRWR if approved by the HRWR manufacturer. A representative of the HRWR manufacturer shall be present during any large

placement, placement of slabs, or during times of unusual circumstance which may require changes to the product formulation.

2. Manufacturers:
 - a. Master Builders, Inc.
 - b. W. R. Grace & Co.
 - c. Sika Corporation.
 - d. Silica Fume: Silica fume mineral admixture shall be Rheomac SF100 as manufactured by Master Builders, Inc., Cleveland, Ohio, or Force 10,000 by Grace Construction Products. The silica fume manufacturer shall provide a certificate of quality stating that the silica fume meets the chemical and physical requirements of ASTM C1240. Silica fume shall come from the same source throughout the project. Silica fumes shall be added to the mix at a rate of 10% of cement content. High range water reducing admixture must be used with silica fume. In addition, normal water reducing agents may be required prior to addition of HRWR to facilitate proper mixing, placing, and consolidation of concrete.
3. Waterstops
 - a. Flexible PVC Waterstop: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes. Unless indicated otherwise, provide the following configurations.
 - b. Construction Joints:
 - 1) Profile: Ribbed without center bulb
 - 2) Width: 6-inches
 - 3) Minimum thickness: 3/8-inch
4. Expansion Joint:
 - a. Profile: Ribbed with center bulb.
 - b. Width: 9 inches
 - c. Minimum thickness: 3/8-inch
5. Manufacturers:
 - a. PVC Waterstop:
 - 1) Greenstreak.
 - 2) Meadows: W. R. Meadows, Inc.
 - 3) Murphy: Paul Murphy Plastics Co.
 - 4) Progress Unlimited Inc.
 - 5) Sternson Group.
 - 6) Tamms Industries Co.; Div. of LaPorte Construction Chemicals North America, Inc.
 - 7) Vinylex Corporation.
 - 8) Westec Barrier Technologies; Div. of Western Textile Products, Inc.

2.2 SELF-EXPANDING STRIP WATERSTOP (HYDROPHILIC): SELF-EXPANDING STRIP WATERSTOP SHALL BE USED ONLY WHERE SPECIFICALLY INDICATED. MANUFACTURED RECTANGULAR OR TRAPEZOIDAL STRIP, SODIUM BENTONITE OR OTHER HYDROPHYLIC MATERIAL FOR ADHESIVE BONDING TO CONCRETE.

- A. Products:
 1. Volclay Waterstop-RX; Colloid Environmental Technologies Co.
 2. Swellseal Joint; De Neef Construction Chemicals (U.S.) Inc.
 3. Adeka Ultra Seal; Mitsubishi International Corporation
- B. Curing Materials
 1. Sheet Curing Material: Conforming to ASTM C171.
 - a. Waterproof paper
 - b. Polyethylene film
 - c. White burlap polyethylene film

2. Membrane Curing Compounds: Membrane curing compound conforming to ASTM C309; having a color to indicate coverage when applied; non staining; applied according to the manufacturer's recommendations. No curing compound shall be used on walls which are to receive a plaster mix finish. When tested according to ASTM C156, the curing compound shall provide a film which has retained, within the specimen, the following percentages of moisture present when the curing compound was applied:
 - a. At least 97% at the end 24 hours
 - b. At least 95% at the end of three (3) days
 - c. At least 91% at the end of seven (7) days
3. Concrete Curing and Sealing Compound: Where a sealer is necessary, use a concrete curing and sealing compound. Application of this product shall be in accordance with the manufacturer's recommendations.
 - a. Interior Concrete Surfaces: Sonneborn Kure-N-Seal W, by BASF The Chemical Company.
 - b. Exterior Concrete Surfaces: Sonneborn Kure 1315, by BASF The Chemical Company.
 - c. Concrete Surfaces Exposed to Chemicals: Sonneborn Kure-N-Harden by BASF The Chemical Company.
 - d. Finishing Aid: Spraying material designed to form a monomolecular film on fresh concrete that reduces the rate of evaporation of surface moisture prior to finishing; conforming to Confilm, as manufactured by Master Builders, Inc. This material is not a curing compound. Concrete must be cured as specified
4. Related Materials
 - a. Bonding Agent
 - 1) Install according to the manufacturer's recommendations and written instructions.
5. Bonding agent shall be Sika Armatec 110 EpoCem by Sika Corporation.
6. Epoxy Bonding Adhesive
 - a. ASTM C881, 2-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
 - 1) Types I and II, non-load bearing
 - 2) IV and V, load bearing, for bonding
 - 3) Hardened or freshly mixed concrete to hardened concrete
7. Reglets
 - a. Fabricate reglets of not less than 0.0217-inch thick, galvanized steel sheet
 - b. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
8. Sleeves and Blockouts
 - a. Formed with galvanized metal, galvanized pipe, polyvinyl chloride pipe, fiber tubes or wood
9. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages
 - a. Sized as required
 - b. Shall be of strength and character to maintain formwork in place while placing concrete

2.3 REPAIR MATERIALS STRUCTURAL CONCRETE REPAIR MATERIAL: NON SHRINK, NON SLUMP, NON METALLIC, QUICK SETTING PATCHING MORTAR; AS APPROVED BY THE MANUFACTURER FOR EACH APPLICATION AND APPLIED ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.

- A. Products:
 1. Sikatop 123 by Sika Corporation
 2. Five Star Structural Concrete by Five Star Products, Inc
- B. Concrete Mixtures, General

1. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
 - a. Required average strength above specified strength
 - 1) Based on a record of past performance
 - a) Determination of required average strength above specified strength shall be based on the standard deviation record of the results of at least 30 consecutive strength tests in accordance with ACI 318, Chapter 5.3 by the larger amount defined by formulas 5-1 and 5-2.
 - 2) Based on laboratory trial mixtures
 - a) Proportions shall be selected on the basis of laboratory trial batches prepared in accordance with ACI 318, Chapter 5.3.3.2 to produce an average strength greater than the specified strength f'_c by the amount defined in table 5.3.2.2.
 - 3) Proportions of ingredients for concrete mixes shall be determined by an independent testing laboratory or qualified concrete supplier.
 - 4) For each proposed mixture, at least 3 compressive test cylinders shall be made and tested for strength at the specified age.
 - a) Additional cylinders may be made for testing for information at earlier ages.
2. Cementitious Materials
 - a. Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows, unless specified otherwise:
 - 1) Fly Ash: 25 percent
 - 2) Combined Fly Ash and Pozzolan: 25 percent
 - 3) Ground Granulated Blast-Furnace Slag: 50 percent
 - 4) Combined Fly Ash or Pozzolan and Ground Granulated Blast-Furnace Slag: 50 percent
 - 5) Portland cement minimum, with fly ash or pozzolan not exceeding 25 percent
 - 6) Silica Fume: 10 percent
 - 7) Combined Fly Ash, Pozzolans, and Silica Fume: 35 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent
 - 8) Combined Fly Ash or Pozzolans, Ground Granulated Blast-Furnace Slag, and Silica Fume: 50 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent
3. Limit water-soluble, chloride-ion content in hardened concrete to:
 - a. 0.30 percent by weight of cement if concrete will have no exposure to chlorides (typical)
 - b. 0.15 percent by weight if concrete will be exposed to chlorides
 - c. 1.0 percent by weight if concrete will have no exposure to chlorides and will be continually dry and protected.
4. Admixtures
 - a. Use admixtures according to manufacturer's written instructions.
 - b. Do not use admixtures which have not been incorporated and tested in accepted mixes.
 - c. Use water-reducing high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
 - d. Use water-reducing and retarding admixture when required by high temperatures, low humidity or other adverse placement conditions.
 - e. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
 - f. Use corrosion-inhibiting admixture in concrete mixtures where indicated.

2.4 CONCRETE MIXTURES

A. Design Criteria

1. Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, admixtures and water, as specified. All Class A and C concrete shall include high range water reducer (HRWR).
2. ACI 211.1 shall be the basis for selecting the proportions for concrete made with aggregates of normal and high density and of workability suitable for usual cast in place structures.
3. The design of the concrete shall be consistent with the minimum requirements of strength and proportions stated herein and in accordance with ACI Standard 211.1 "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete," subject to maximum water cement ratio, minimum cement content and minimum strengths specified.
4. The workability of any mix shall be as required for the specific placing conditions and the method of placement. The concrete shall have the ability to be worked readily into corners and around reinforcing steel without the segregation of materials or the collection of free water on the surface. Compliance with specified slump limitations shall not necessarily designate a satisfactory mix.
5. In no case shall the amount of coarse material produce harshness in placing or honeycombing in the structure, when forms are removed.
6. The maximum amount of coarse aggregate (dry loose volume) per cubic foot of finished concrete shall not exceed 0.82 cubic feet.
7. The maximum amount of water includes the water in the aggregate, with the aggregates in a saturated, surface-dry condition.
8. The maximum water content shall be the amount added at the mixer, plus the free water in the aggregate, and minus the absorption of the aggregate based on a 30 minute absorption period. No allowance shall be made for the evaporation of water after batching. If additional water is required to obtain the desired slump, a compensating amount of cement shall also be added. In no case shall the maximum water cement ratio exceed the specified maximum or that of the approved mix design. No additional compensation shall be made for additional cement.
9. Concrete of 3000 psi or stronger shall contain air entraining admixtures.
10. When job conditions dictate, water-reducing and set-controlling admixtures may be used. Only specified admixtures shall be used. Admixtures shall be batched at the batch plant.
11. Use silica fume where indicated on drawings. A separate mix design for silica fume concrete shall be made and approved prior to placement of any silica fume concrete. The trial mix shall be in accordance with this specification and in accordance with the silica fume manufacturer. Silica fume concrete shall have high range water reducing admixture and air-entraining admixture in the mix. In addition, normal water-reducing admixtures may be required prior to addition of HRWR to facilitate proper mixing, placing, and consolidation of concrete. No reduction in cement content shall be allowed. The amount of silica fume in the mix may be added to the cement when determining the water-cement ratio. The original water to cementitious material ratio shall not be exceeded.
12. Concrete shall be capable of developing two thirds of the required 28-day compressive strength in seven days.

B. Concrete Classifications

Class	Min. 28-Day Compressive Strength (psi)	Max. Size Aggregate (inches)	Max. Water : Cement Ratio	Max. Slump* (inches)	Min. Sacks of Cement** Per CY
A	4500	1.5*** Size No. 467	0.42	5	5.5
B	3000	1.5 Size No. 467	0.47	4	5.5

C	4000	1.0 Size No. 57	0.45	4	6.0
D	5000	0.75 Size No. 67	0.47	5	6.5
E	1500	1.5 Size No. 467	0.70	4	4.0
F	4000	0.375 Size No. 8	0.50	8	6.75
G	4500	1.5 Size No. 467	0.42	4	6.5

*Maximum slump with high range water reducing admixture may be increased to 7" - 9".

** Provide one additional sack of cement per cubic yard if concrete must be deposited in water.

*** Maximum aggregate size may be reduced to 1" if 6 sacks of cement per CY are used.

2.5 CONCRETE USAGE

- A. Class A Use: All reinforced concrete unless otherwise specified
- B. Class B Use: Sidewalks, Curbs, Driveways, Concrete Encasement
- C. Class C Use: Pumped Concrete, Drilled Shafts, Thin Wall Sections
- D. Class D Use: Precast Concrete and Precast Panels
- E. Class E Use: Cradling, Blocking, Foundation Seal, Lean Concrete Backfill
- F. Class F Use: Underground Duct Banks
- G. Class G Use: Anchor Reaction Blocks
- H. Required Average Compressive Strength
 - 1. All concrete is required to have an average compressive strength greater than the specified strength. The required average compressive strength shall be established according to the requirements of ACI 301, 4.2.3.3.
 - 2. Standard Deviation: If the production facility has records of field tests performed within the past 12 months and spanning a period of not less than 60 calendar days for a class of concrete within 1000 psi of that specified for the work, calculate a standard deviation and establish the required average strength f_{cr}' in accordance with ACI 301, 4.2.3.2 and 4.2.3.3.a. If field test records are not available, select the required average strength from ACI 301, Table 4.2.3.3.b.
- I. Documentation of Required Average Compressive Strength
 - 1. Documentation indicating the proposed concrete proportions will produce an average compressive strength equal to or greater than the required average compressive strength, shall consist of field strength records or trial mixture.
 - 2. Field Strength Records
 - a. Document field strength records according to ACI 301, 4.2.3.4.a and including the following.
 - 1) Field test data shall not be older than one year.
 - 2) If field test data are available and represent a single group of at least 10 consecutive strength tests for one mixture, using the same materials, under

the same conditions, and encompassing a period of not less than 60 days, verify that the average of the field test results equals or exceeds f_{cr}' . Submit for acceptance the mixture proportions along with the field test data.

- 3) If the field test data represent two groups of compressive strength tests for two mixtures, plot the average strength of each group versus the water-cementitious materials ratio of the corresponding mixture proportions and interpolate between them to establish the required mixture proportions for f_{cr}' .

3. Trial Mixtures

- a. Establish trial mixture proportions according to ACI 301, 4.2.3.4.b and including the following.
 - 1) Make at least three trial mixtures complying with performance and design requirements. Each trial mixture shall have a different cementitious material content. Select water-cementitious materials ratios that will produce a range of compressive strengths encompassing the required average compressive strength f_{cr}' .
 - 2) Submit a plot of a curve showing the relationship between water-cementitious materials ratio and compressive strength.
 - 3) Establish mixture proportions so that the maximum water-cementitious materials ratio is not exceeded when the slump is at the maximum specified.
- b. Laboratory samples shall be taken in accordance with the trial mix designs for laboratory testing purposes.
- c. The fresh concrete shall be tested for Slump (ASTM C143) and Air Content (ASTM C173 and ASTM C231). Strength test specimens shall be made, cured and tested for seven (7) and 28-day strength in accordance with ASTM C192, ASTM C39, and ASTM C293.
- d. Suitable facilities shall be provided for readily obtaining representative samples of aggregate from each of the weigh batchers for test purposes and for obtaining representative samples of concrete for uniformity tests. The necessary platforms, tools, and equipment for obtaining samples shall be furnished. Aggregates shall be tested in accordance with ASTM C289.
- e. The cement contents specified are minimum values. If additional quantities are required to obtain the specified strengths, supply the cement at no additional cost to the Owner.
- f. A trial mix shall be designed by an independent testing laboratory, retained and paid by the Contractor and approved by the Owner. The testing laboratory shall submit verification that the materials and proportions of the trial concrete mix design meet the specifications.
- g. From these trial mix tests, the ratios between 7 day and 28 day strengths shall be established. The seven (7) day strength which corresponds to the required 28 day strength shall be determined.
- h. The final results of the trial mix design shall be submitted to the Engineer at least ten (10) days prior to the scheduled beginning of concrete placement and shall be approved by the Engineer prior to the placement of any concrete.

4. Revisions to concrete mixtures

- a. When less than 15 compressive strength tests results for a given class of concrete are available from the current project:
 - 1) If any of the following criteria are met, take immediate steps to increase average compressive strength of the concrete.
 - a) A 7-day compressive strength test result multiplied by 1.5 falls below the required 28-day compressive strength.
 - b) A 28-day compressive strength tests result is deemed not satisfactory.
- b. When at least 15 compressive strength test results for a given class of concrete become available from the current project:
 - 1) Calculate the actual average compressive strength, standard deviation and required average compressive strength using the previous 15 consecutive

strength tests. Submit results in graphical form with each 28-day test result for that class of concrete.

- 2) If any of the following criteria are met, take immediate steps to increase average compressive strength of the concrete.
 - a) A 7-day compressive strength test result multiplied by the average job-to-date ratio of 7-day to 28-day compressive strength falls below the required 28-day compressive strength.
 - b) A 28-day compressive strength tests result is deemed not satisfactory.
 - c) The average compressive strength falls below the required average compressive strength.
- c. When revisions to the mix design are required, notify the Engineer in writing of the corrective actions taken

J. Fabricating Reinforcement (ENGINEER: REFERENCE 03 21 00 REINFORCING STEEL)

K. Fabrication of Embedded Metal Assemblies

1. Where aluminum anchors, aluminum shapes, or aluminum electrical conduits are embedded in concrete, paint aluminum contact surfaces with zinc rich primer. Allow the paint to thoroughly dry before placing the aluminum in contact with the concrete.
2. Paint steel or other ferrous metal to be mounted on or placed in contact with dry/cured concrete, and coat in accordance with Section _____, PROTECTIVE COATINGS prior to installation.

L. Concrete Mixing

1. Mixers may be stationary, truck, or paving mixers of approved design. They shall be capable of combining the materials into a uniform mixture and of discharging without mixture segregation. Stationary and paving mixers shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixers or mixing plant shall include a device for automatically counting the total number of batches of concrete mixed. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer on the name plate.

M. The mixing time for stationary mixers shall be based upon the mixer's ability to produce uniform concrete throughout the batch and from batch to batch. For guidance purposes, the manufacturer's recommendations, or one (1) minute for one (1) cubic yard plus 1/4 minute for each additional cubic yard may be used. Final mixing time shall be based on mixer performance. Mixers shall not be charged in excess of the capacity specified by the manufacturer.

N. When a stationary mixer is used for partial mixing of the concrete (shrink mixed), the stationary mixing time may be reduced to the minimum necessary to intermingle the ingredients (about 30 seconds).

O. When a truck mixer is used, either for complete mixing (transit-mixed) or to finish the partial mixing in a stationary mixer and in the absence of uniformity test data, each batch of concrete shall be mixed not less than 70 nor more than 100 revolutions of the drum, at the rate of rotation designated by the manufacturer of the equipment as mixing speed. If the batch is at least 1/2 cubic yard less than the rated capacity, in the absence of uniformity test data, the number of revolutions at mixing speed may be reduced to no less than 50. Additional mixing shall be performed at the speed designated by the manufacturer of the equipment as agitating speed. When necessary for proper control of the concrete, mixing of transit-mixed concrete shall not be permitted until the truck mixer is at the site of the concrete placement. Truck mixers shall be equipped with accurate revolution counters.

P. Paving mixers may be either single compartment drum or multiple compartment drum type. A sled or box of suitable size shall be attached to the mixer under the bucket to catch any concrete spillage that may occur when the mixer is discharging concrete into the bucket. Multiple

compartment drum paving mixers shall be properly synchronized. The mixing time shall be determined by time required to transfer the concrete between compartments of the drum.

- 2.6 VEHICLES USED IN TRANSPORTING MATERIALS FROM THE BATCHING PLANT TO THE PAVING MIXERS SHALL HAVE BODIES OR COMPARTMENTS OF ADEQUATE CAPACITY TO CARRY THE MATERIALS AND TO DELIVER EACH BATCH, SEPARATED AND INTACT, TO THE MIXER. CEMENT SHALL BE TRANSPORTED FROM THE BATCHING PLANT TO THE MIXERS IN SEPARATE COMPARTMENTS WHICH ARE EQUIPPED WITH WINDPROOF AND RAIN PROOF COVERS

PART 3 - EXECUTION

3.1 PREPARATION

- A. Notify the Owner's representative upon completion of various portions of the work required for placing concrete, so that inspection may be made as early as possible. Keep the Owner's representative informed of the anticipated concrete placing schedules.
- B. All items, including lines and grades, forms, waterstops, reinforcing, inserts, piping, electrical, plumbing and the Contractor's concreting materials and equipment shall be in compliance with the plans and specifications before proceeding.
- C. Do not place any concrete until formwork and the placing reinforcement in that unit is complete. Place no concrete before the completion of all adjacent operations which might prove detrimental to the concrete.
- D. Brilliantly light the work site so that all operations are plainly visible when concrete mixing, placing, and finishing continues after daylight. Whenever possible, concrete finishing shall be completed in daylight hours.
- E. When placing concrete, the forms shall be clean and entirely free from all chips, dirt, sawdust and other extraneous matter. Forms for slab, beam and girder construction shall not have tie wire cuttings, nails, or any other matter which would mar the appearance of the finished construction. Clean forms and keep them free of any foreign matter during concrete placing.
- F. The concrete shall be mixed in quantities required for immediate use. Any concrete which is not in place within the time limits specified shall not be used. Concrete shall not be re-tempered.
- G. Concrete shall not be placed if impending weather conditions would impair the quality of the finished work.
- H. Unless otherwise provided, the following requirements shall govern the time sequence on which construction operations shall be carried.
 - 1. Forms for walls or columns shall not be erected on concrete footings until the concrete in the footing has cured for at least two (2) curing days. Concrete may be placed in a wall or column as soon as the forms and reinforcing steel placements are approved.

- 3.2 STEEL BEAMS OR FORMS AND FALSEWORK FOR SUPERSTRUCTURES SHALL NOT BE ERECTED ON CONCRETE SUBSTRUCTURES UNTIL THE SUBSTRUCTURE CONCRETE HAS CURED FOR AT LEAST FOUR (4) CURING DAYS. FALSEWORK REQUIRED FOR SUPERSTRUCTURES SHALL NOT BE ERECTED UNTIL THE SUBSTRUCTURE HAS CURED FOR FOUR (4) CURING DAYS, AND SHALL NOT BE REMOVED UNTIL THE SUPERSTRUCTURE HAS CURED INSTALLATION

- A. Formwork

1. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.
2. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
 - a. Vertical alignment
 - 1) Lines, surfaces and arises less than 100 feet in height - 1 inch.
 - 2) Outside corner of exposed corner columns and control joints in concrete exposed to view less than 100 feet in height - 1/2 inch.
 - 3) Lines, surfaces and arises greater than 100 feet in height - 1/1000 times the height but not more than 6 inches.
 - 4) Outside corner of exposed corner columns and control joints in concrete exposed to view greater than 100 feet in height - 1/2000 times the height but not more than 3 inches.
 - b. Lateral alignment
 - 1) Members - 1 inch.
 - 2) Centerline of openings 12 inches or smaller and edge location of larger openings in slabs - 1/2 inch.
 - 3) Sawcuts, joints, and weakened plane embedments in slabs - 3/4 inch.
 - c. Level alignment
 - 1) Elevation of slabs-on-grade - 3/4 inch.
 - 2) Elevation of top surfaces of formed slabs before removal of shores - 3/4 inch.
 - 3) Elevation of formed surfaces before removal of shores - 3/4 inch.
 - d. Cross-sectional dimensions: Overall dimensions of beams, joists, and columns and thickness of walls and slabs.
 - 1) 12 inch dimension or less - plus 1/2 inch to minus 1/4 inch.
 - 2) Greater than 12 inch to 3 foot dimension - plus 1/2 inch to minus 3/8 inch.
 - 3) Greater than 3 foot dimension - plus 1 inch to minus 3/4 inch.
 - e. Relative alignment
 - 1) Stairs
 - a) Difference in height between adjacent risers - 1/8 inch.
 - b) Difference in width between adjacent treads - 1/4 inch.
 - c) Maximum difference in height between risers in a flight of stairs - 3/8 inch.
 - d) Maximum difference in width between treads in a flight of stairs - 3/8 inch.
 - 2) Grooves
 - a) Specified width 2 inches or less - 1/8 inch.
 - b) Specified width between 2 inches and 12 inches - 1/4 inch.
 - 3) Vertical alignment of outside corner of exposed corner columns and control joint grooves in concrete exposed to view - 1/4 inch in 10 feet.
 - 4) All other conditions - 3/8 inch in 10 feet.
3. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
 - a. Class B, 1/4 inch for smooth-formed finished surfaces.
 - b. Class C, 1/2 inch for rough-formed finished surfaces.
4. Construct forms tight enough to prevent loss of concrete mortar.
5. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 - a. Install keyways, reglets, recesses, and the like, for easy removal.
 - b. Do not use rust-stained steel form-facing material.
6. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

7. Construct formwork to cambers shown or specified on the Drawings to allow for structural deflection of the hardened concrete. Provide additional elevation or camber in formwork as required for anticipated formwork deflections due to weight and pressures of concrete and construction loads.
8. Foundation Elements: Form the sides of all below grade portions of beams, pier caps, walls, and columns straight and to the lines and grades specified. Do no earth form foundation elements unless specifically indicated on the Drawings.
9. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
10. Chamfer exterior corners and edges of permanently exposed concrete.
11. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
12. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
13. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
14. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement, anchoring devices, and embedded items.
 - a. Do not apply form release agent where concrete surfaces are scheduled to receive subsequent finishes which may be affected by agent. Soak contact surfaces of untreated forms with clean water. Keep surfaces wet prior to placing concrete.

B. Embedded Items

1. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - a. Install anchor rods, accurately located, to elevations required and complying with tolerances in AISC 303, Section 7.5.
 - 1) Spacing within a bolt group: 1/8 inch
 - 2) Location of bolt group (center): 1/2 inch
 - 3) Rotation of bolt group: 5 degrees
 - 4) Angle off vertical: 5 degrees
 - 5) Bolt projection: ± 3/8 inch
 - b. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.

C. Removing and Reusing Forms

1. Do not backfill prior to concrete attaining 70 percent of its 28-day design compressive strength.
2. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 degrees Fahrenheit for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
 - a. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
 - b. Do not remove formwork supporting conventionally reinforced concrete until concrete has attained 70 percent of its specified 28 day compressive strength as established by tests of field cured cylinders. In the absence of cylinder tests, supporting formwork shall remain in place until the concrete has cured at a

temperature of at least 50 degrees Fahrenheit for the minimum cumulative time periods given in ACI 347, Section 3.7.2.3. Add the period of time when the surrounding air temperature is below 50 degrees Fahrenheit, to the minimum listed time period. Formwork for 2-way conventionally reinforced slabs shall remain in place for at least the minimum cumulative time periods specified for 1-way slabs of the same maximum span.

- c. Immediately reshore 2-way conventionally reinforced slabs after formwork removal. Reshores shall remain until the concrete has attained the specified 28 day compressive strength.
 - d. Minimum cumulative curing times may be reduced by the use of high-early strength cement or forming systems which allow form removal without disturbing shores, but only after the Contractor has demonstrated to the satisfaction of the Engineer that the early removal of forms will not cause excessive sag, distortion or damage to the concrete elements.
 - e. Completely remove wood forms. Provide temporary openings if required.
 - f. Provide adequate methods of curing and thermal protection of exposed concrete if forms are removed prior to completion of specified curing time.
 - g. Reshore areas required to support construction loads in excess of 20 pounds per square foot to properly distribute construction loading. Construction loads up to the rated live load capacity may be placed on unshored construction provided the concrete has attained the specified 28 day compressive strength.
 - h. Obtaining concrete compressive strength tests for the purposes of form removal is the responsibility of the Contractor.
 - i. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
3. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
 4. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Engineer.

D. Shores and Reshores

1. The Contractor is solely responsible for proper shoring and reshoring.
2. Comply with ACI 318 and ACI 301 for design, installation, and removal of shoring and reshoring.
 - a. Do not remove shoring or reshoring until measurement of slab tolerances is complete.
3. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

E. Steel Reinforcement

1. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
 - a. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.
2. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.
3. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
 - a. Weld reinforcing bars according to AWS D1.4, where indicated. Only steel conforming to ASTM A706 may be welded.
4. Installation tolerances
 - a. Top and bottom bars in slabs, girders, beams and joists:
 - 1) Members 8 inches deep or less: $\pm 3/8$ inch
 - 2) Members more than 8 inches deep: $\pm 1/2$ inch

- b. Concrete Cover to Formed or Finished Surfaces: $\pm 3/8$ inches for members 8 inches deep or less; $\pm 1/2$ inches for members over 8 inches deep, except that tolerance for cover shall not exceed $1/3$ of the specified cover.
 - 5. Concrete Cover
 - a. Reinforcing in structural elements deposited against the ground: 3 inches
 - b. Reinforcing in formed beams, columns and girders: 1-1/2 inches
 - c. Grade beams and exterior face of formed walls and columns exposed to weather or in contact with the ground: 2 inches
 - d. Interior faces of walls: 1 inches
 - e. Slabs: 3/4 inches
 - 6. Splices: Provide standard reinforcement splices by lapping and tying ends. Comply with ACI 318 for minimum lap of spliced bars where not specified on the documents. Do not lap splice no. 14 and 18 bars.
 - 7. Field Welding of Embedded Metal Assemblies
 - a. Remove all paint and galvanizing in areas to receive field welds.
 - b. Field Prepare all areas where paint or galvanizing has been removed with the specified paint or cold galvanizing compound, respectively.
- F. Joints
 - 1. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
 - 2. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer.
 - a. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
 - b. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
 - c. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 - d. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 - e. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
 - f. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 3. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat 1-1/2 of dowel length to prevent concrete bonding to 1 side of joint.
- G. Waterstops
 - 1. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.
 - 2. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening, and firmly pressing into place. Install in longest lengths practicable.
- H. Adhesive Anchors
 - 1. Comply with the manufacturer's installation instructions on the hole diameter and depth required to fully develop the tensile strength of the adhesive anchor or reinforcing bar.
 - 2. Properly clean out the hole utilizing a wire brush and compressed air to remove all loose material from the hole, prior to installing adhesive material.

I. Concrete Placement

1. Cold Weather
 - a. If air temperature is at or below 40 degrees F, cold weather concreting shall be performed in accordance with ACI 306R.
 - b. No concrete shall be mixed or placed when the atmospheric temperature is at or below 35 degrees F. The temperature shall be taken in the shade away from artificial heat.
 - c. In cases where the temperature drops below 40 degrees F after the concreting operations have been started, sufficient canvas and framework or other type of housing shall be furnished to enclose and protect the structure, in accordance with the requirements of ACI 306R. Sufficient heating apparatus such as stoves, salamanders, or steam equipment and fuel to provide heat shall be supplied. The concrete shall be protected when placed under all weather conditions. Should concrete placed under such conditions prove unsatisfactory, remove and replace the concrete at no cost to the Owner.
 - d. When mixing with the air temperature below 40 degrees F, water used for mixing shall be heated to raise the concrete temperature to 70 degrees F. The temperature of the mixing water shall not exceed 165 degrees F when entering the mixer.
 - e. If heating the mixing water only does not raise the placing temperature of the concrete to 70 degrees F, the aggregate must also be heated, either by steam or dry heat, to raise the placing temperature of the concrete to the required temperature. In no case shall the aggregate temperature exceed 150 degrees F as it enters the mixer. The heating apparatus shall heat the mass of the aggregate uniformly and preclude the occurrence of hot spots which burn the material.
 - f. Salts, chemicals, or other foreign materials shall not be mixed with the concrete to preventing freezing. Calcium chloride is not permitted.
2. Hot Weather
 - a. Hot weather is defined as any combination of high air temperature, low relative humidity and wind velocity that impairs the quality of the concrete. Hot weather concreting shall be in accordance with ACI 305R. Concrete shall be placed in the forms without the addition of any more water than that required by the design (slump). No excess water shall be added on the concrete surface for finishing. Control of initial set of the concrete and extending the time for finishing operations may be accomplished with the use of approved water reducing and set retarding admixture, as specified.
 - b. Maximum time intervals between the addition of mixing water and/or cement to the batch, and the placing of concrete in the forms shall not exceed the following (excluding HRWR admixture use):

Concrete Temperature	Maximum Time From Water Batch to Placement
Non-Agitated Concrete	
Up to 80° F	30 Minutes
Over 80° F	15 Minutes
Agitated Concrete	
Up to 75° F	90 Minutes
75° to 89° F	60 Minutes

- c. The use of an approved set-retarding admixture will permit the extension of the above time maximums by 30 minutes, for agitated concrete only.
- d. The use of an approved high range water reducing (HRWR) admixture will allow placement time extensions as determined by the manufacturer.
- e. The maximum temperature of concrete shall not exceed 90 degrees F at the time the concrete is placed. The temperatures of the mixing water shall be reduced by the use of chilled water or ice.

- f. The maximum temperature of concrete with high range water reducing admixture shall not exceed 100 degrees F at the time concrete is placed.
 - g. Under extreme heat, wind, or humidity conditions, concreting operations may be suspended if the quality of the concrete being placed is not acceptable.
3. Handling and Transporting
- a. Delivery tickets shall be required for each batch and shall be in accordance with ASTM C94, Section 16. Each delivery ticket must show plainly the amount of water, in gallons, which can be added to the mixer truck at the site without exceeding the maximum water cement ratio approved for that mix design. Amount of water added must be in proportion to contents of truck.
 - b. Arrange and use chutes, troughs, or pipes as aids in placing concrete so that the ingredients of the concrete are not segregated. They shall be steel or steel lined. When steep slopes are necessary, equip the chutes with baffles or make in short lengths that reverse the direction of movement. Extend open troughs and chutes, if necessary, inside the forms or through holes left in the forms. Terminate the ends of these chutes in vertical downspouts.
 - c. Keep chutes, troughs and pipes clean and free from coatings of hardened concrete by thoroughly flushing with water before and after placement. Discharge water used for flushing away from the concrete in place.
 - d. Concrete pumping is permitted and shall comply with ACI 304.2R.
 - e. Carting or wheeling concrete batches on completed concrete floor slab shall not be permitted until the slab has aged at least four (4) curing days. Unless pneumatic tired carts are used, wheel the carts on timber planking so that the loads and impact are distributed over the slab. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.
4. Depositing
- a. The method and manner of placing shall prevent segregation or separation of the aggregate or the displacement of the reinforcement. Use drop chutes of rubber or metal when necessary. Prevent the spattering of forms or reinforcement bars if the spattered concrete dries or hardens before it is incorporated into the mass.
 - b. Fill each part of the forms by directly depositing concrete as near its final position as possible. Work the coarse aggregate back from the face and force the concrete under and around the reinforcement bars without displacing them. Depositing large quantities at one point in the forms, then running or working it along the forms shall not be permitted.
 - c. After the concrete has taken initial set, the forms shall not be jarred. No force or load shall be placed upon projecting reinforcement.
 - d. Deposit the concrete through vertical drop chutes of rubber or metal of satisfactory size when operations involve placing concrete from above, such as directly into an excavated area, or through the completed forms, particularly in walls, piers, columns, and similar structures. Drop chutes shall be made in sections or provided in several lengths so that the outlet may be adjusted to proper heights during placing.
 - e. Except for drilled shafts, concrete shall not be dropped free more than 10 feet when HRWR admixture is used or 5 feet without HRWR. Place in continuous horizontal layers with a depth of from 1 to 3 feet, depending upon the wall thickness. Each layer shall be soft when a new layer is placed upon it. No more than one (1) hour shall elapse between the placing of successive concrete layers in any portion of the structures included in continuous placement.
 - f. Place required sections in one continuous operation to avoid additional construction joints.
 - g. If excessive bleeding causes water to form on the surface of the concrete in tall forms, make the mix dryer to reduce the bleeding. In tall walls, place the concrete to a point about 1 foot below the top of the wall and allow to settle for one to two (1-2) hours. Resume and complete concreting before set occurs.
 - h. For slopes greater than two percent, start concrete placement at low end and proceed upslope.

5. Consolidating
 - a. Compact each layer of concrete and flush the mortar to the surface of the forms by continuous-working mechanical vibrators. Vibrators which operate by attachment to forms shall not be used. Apply the vibrator to the concrete immediately after deposit. Move vibrator throughout the layer of the newly placed concrete, several inches into the plastic layer below. Thoroughly work the concrete around the reinforcement, embedded fixtures and into the corners and angles of the forms until it is well-compacted.
 - b. Mechanical vibrators shall not be operated so that they penetrate or disturb previously placed layers which are partially set or hardened. They shall not be used to aid the flow of concrete laterally. The vibration shall be of sufficient duration to completely compact and embed reinforcement and fixtures, but not to an extent causing segregation.
 - c. Keep vibrators constantly moving in the concrete and apply vertically at points uniformly spaced, not farther apart than the radius over which the vibrator is visibly effective. The vibrator shall not be held in one location longer than required to produce a liquefied appearance on the surface.
 - d. When submerged in concrete, internal vibrators shall maintain a frequency of not less than 6,000 impulses per minute for spuds with diameters greater than 5" and 10,000 impulses for smaller spuds. The vibration intensity (amplitude) shall be sufficient to produce satisfactory consolidation.
 - e. Provide one (1) vibrator (powered pneumatically or electrically) for each 10 cubic yards of concrete per hour being placed. Provide at least one (1) vibrator, which may be of the gasoline powered type, as a standby for each two vibrators in service. To produce satisfactory consolidation, and based upon the observed performance, the Owner's representative may require the use of a larger sized and powered vibrator.
 - f. Check vibrators intended for regular service or standby service before beginning concreting operations.
6. Placement in Water
 - a. Deposit concrete in water only when dry conditions cannot be obtained. The forms, cofferdams, or caissons shall be sufficiently tight to prevent any water flowing through the space where concrete is to be deposited. Pumping of water shall not be permitted while the concrete is being placed, nor until it has set for at least 36 hours.
 - b. Carefully place the concrete compact mass using a tremie, closed bottom dumping bucket, or another approved method which does not permit the concrete to fall through the water without protection. The concrete shall not be disturbed after being deposited. Regulate depositing to maintain horizontal surfaces.
 - c. When a tremie is used, it shall consist of a tube constructed in sections having water-tight connections. The means of supporting the tremie shall permit the movement of the discharge end over the entire top surface of the work, and shall allow the tremie to be rapidly lowered to retard the flow. The number of times it is necessary to shift the location of the tremie shall be held to a minimum for any continuous placement of concrete. During the placing of concrete, keep the tremie tube full to the bottom of the hopper. When a batch is dumped into the hopper, slightly raise the tremie, but not out of the concrete at the bottom, until the batch discharges to the level of the bottom of the hopper. Stop the flow by lowering the tremie. Continue placing operations until the work is completed.
 - d. When concrete is placed by means of the bottom dump bucket, the bucket shall have a capacity of not less than 1/2 cubic yard. Lower the bucket gradually and carefully until it rests upon the concrete already placed. Raise it very slowly during the discharge travel to maintain still water at the point of discharge and to avoid agitating the mixture.
 - e. Use a sump or other approved method to channel displaced fluid and concrete away from the shaft excavation. Recover slurry and dispose of it as approved. Do not

discharge displaced fluids into or in close proximity to streams or other bodies of water.

7. Placement in Slabs
 - a. Allow concrete in columns, walls and deep beams or girders to stand for at least one (1) hour to permit full settlement from consolidation, before concrete is placed for slabs they are to support. Haunches are considered as part of the slab and shall be placed integrally with them.
 - b. For slabs to be coated inside manholes, junction boxes, and water containing structures, install a moisture barrier prior to slab placement if recommended by the coating manufacturer or required under separate specifications.
 - c. When monolithic slabs are placed in strips, the widths of the strips, unless otherwise specified or indicated, shall insure that concrete in any one strip is not allowed to lie in place for more than one (1) hour before the adjacent strips are placed.
 - d. Immediately before placing concrete, thoroughly dampen the earthen cushion to receive concrete to prevent moisture absorption from the concrete.
 - e. As soon as concrete placing is complete for a slab section of sufficient width to permit finishing operations, level the concrete, strike off, tamp and screed. The screed shall be of a design adaptable to the use intended, shall have provision for vertical adjustment and shall be sufficiently rigid to hold true to shape during use.
 - f. The initial strike off shall leave the concrete surface at an elevation slightly above grade so that, when consolidation and finishing operations are completed, the surface of the slab is at grade elevation.
 - g. Continue tamping and screeding operations until the concrete is properly consolidated and free of surface voids. Bring the surface to a smooth, true alignment using longitudinal screeding, floating, belting, and/or other methods.
 - h. When used, templates shall be of a design which permits early removal so satisfactory finishing at and adjacent to the template is achieved.
 - i. While the concrete is still plastic, straightedge the surface using a standard 10' metal straightedge. Lap each straightedge pass 1/2 of the preceding pass. Remove high spots and fill depressions with fresh concrete and re-float. Continue to check with a straightedge during the final finishing operation, until the surface is true to grade and free of depressions, high spots, voids, or rough spots.
 - j. Check the final surface with a straightedge. Ordinates measured from the face of the straightedge to the surface of the slab shall not exceed 1/16" per foot from the nearest point of contact. The maximum ordinate shall be 1/8" per 10'.
 - k. Unless noted otherwise, where floor drains or hub drains are shown in slabs of buildings, vaults, or treatment basin units and sloping the slab is not indicated, slope slab to drain on a grade of 1/16" per foot with a maximum total slope of 1 1/4". The thickness of slab at floor or hub drain shall be the thickness of slab, as indicated on the plans.
8. Placement in Foundations: Place concrete in deep foundations so that segregation of the aggregates or displacement of the reinforcement is avoided. Provide suitable chutes or vertical pipes. When footings can be placed in dry foundation pits without the use of cofferdams or caissons, forms may be omitted and the entire excavation filled with concrete to the elevation of the top of footing. The placing of concrete bases above seal courses is permitted after the forms are free from water and the seal course cleaned. Execute necessary pumping or bailing during concreting from a suitable sump located outside the forms.
9. Finishing Formed Surfaces; Forms for walls, columns and sides of beams and girders shall be removed as specified in 03 10 00 CONCRETE FORMING AND ACCESSORIES. Patch, repair, finish and clean concrete after form removal. Finish concrete within seven (7) days of form removal. Cure concrete as finishing progresses.
10. Air voids, for all types of finishes, are defects and shall be removed by rubbing or patching.
11. Finish Schedule

Type of Finish	Location
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No Finish	Surfaces which are not visible from the inside or outside of the completed structure or more than 12-inches below finish grade (i.e. back of retaining walls below embankment, etc.)
Smooth Finish	Surfaces exposed to view and areas below to a point 12-inches below grade

12. No Finish: After forms are removed, repair or patch tie holes and defects. Otherwise, no additional finish is required.
13. Smooth Finish: Unless otherwise shown on the schedule above, provide smooth form finish for concrete surfaces to be exposed to view. Surfaces to receive a rubbed finish shall have a smooth form finish. The form facing material shall produce a smooth, hard, uniform texture on the concrete. The arrangement of the facing material shall be orderly and symmetrical with a minimum number of seams. Patch tie holes and defects and remove fins flush with the adjacent surface.
 - a. Form Liner Finish: Finish shall be as specified in 03 10 00 CONCRETE FORMING AND ACCESSORIES.
14. Miscellaneous Concrete Items
 - a. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.
 - b. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
 - c. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.
 - 1) Housekeeping pads: Normal weight concrete (3000 psi), reinforced with #3@16 inches on center set at mid-depth of pad. Trowel concrete to a dense, smooth finish. Set anchor bolts for securing mechanical or electrical equipment during pouring of concrete fill.
 - d. Protective slabs ("Mud slabs"): Normal weight concrete (2500 psi minimum) with a minimum thickness of 3-1/2 inches. Finish slab to a wood float finish.
15. Concrete Protecting and Curing
 - a. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 305.1 for hot-weather protection during curing.
 - b. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.
 - c. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
 - d. Cure concrete according to ACI 308.1, by 1 or a combination of the following methods:
 - 1) Moisture Curing: Keep surfaces continuously moist for not less than 7 days with the following materials:
 - a) Water
 - b) Continuous water-fog spray

- c) Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers
- 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than 7 days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 - a) Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
 - b) Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
 - c) Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.
- 3) Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.3 REPAIR

A. Concrete Surface Repairs

1. Defective Concrete: Repair and patch defective areas when approved by Engineer. Remove and replace concrete that cannot be repaired and patched to Engineer's approval.
2. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part Portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing. No retempering of mortar mix will be allowed.
3. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. AUTHORITY inspector must be present when forms are removed.
 - a. Immediately after form removal, cut-out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension in solid concrete, but not less than 1 inch in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
 - b. Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 - c. Repair defects that affect concrete's durability and structural performance as determined by Engineer.
4. On the outside of junction boxes and other water containing structures that are to receive special protective coatings on their interior, install concrete sealant or vapor barrier as required by the coating manufacturer to prevent groundwater from influencing interior coating performance.
5. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
 - a. Repair finished surfaces containing defects. Surface defects include spalls, pop outs, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.

- b. After concrete has cured at least 14 days, correct high areas by grinding.
 - c. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
 - d. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
 - e. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
- 6. Perform structural repairs of concrete, subject to Engineer's approval, using epoxy adhesive and patching mortar.
 - 7. Repair materials and installation not specified above may be used, subject to Engineer's approval.

3.4 FIELD QUALITY CONTROL

- A. Testing: Authority will engage a qualified testing agency to perform field tests and prepare test reports.
- B. Inspections
 - 1. Steel reinforcement placement
 - 2. Headed bolts and studs
 - 3. Verification of use of required design mixture
 - 4. Concrete placement, including conveying and depositing
 - 5. Curing procedures and maintenance of curing temperature
 - 6. Verification of concrete strength before removal of shores and forms from beams and slabs
- C. Concrete Tests: Perform testing of composite samples of fresh concrete obtained according to ASTM C172 according to the following requirements:
 - 1. Testing Frequency: Obtain 1 composite sample for each day's pour of each concrete mixture exceeding 5 cubic yard, but less than 25 cubic yard, plus 1 set for each additional 50 cubic yard or fraction thereof.
 - 2. Slump: ASTM C143; 1 test at point of placement for each composite sample, but not less than 1 test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 - 3. Air Content: ASTM C231, pressure method, for normal-weight concrete; 1 test for each composite sample, but not less than 1 test for each day's pour of each concrete mixture.
 - 4. Concrete Temperature: ASTM C1064; 1 test hourly when air temperature is 40 degrees Fahrenheit and below and when 80 degrees Fahrenheit and above, and 1 test for each composite sample.
 - 5. Compression Test Specimens: ASTM C31.
 - a. Cast and laboratory cure 4 cylinders for each composite sample.
 - 1) Do not transport field cast cylinders until they have cured for a minimum of 24 hours.
 - 6. Compressive-Strength Tests: ASTM C39;
 - a. Test 1 cylinder at 7 days.
 - b. Test 2 cylinders at 28 days.
 - c. Hold 1 cylinder for testing at 56 days as needed.

7. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 8. Strength of each concrete mixture will be satisfactory if every average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
 9. Report test results in writing to Engineer, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
 10. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42 or by other methods as directed by Engineer.
 - a. When the strength level of the concrete for any portion of the structure, as indicated by cylinder tests, falls below the specified requirements, provide improved curing conditions and/or adjustments to the mix design as required to obtain the required strength. If the average strength of the laboratory control cylinders falls so low as to be deemed unacceptable, follow the core test procedure set forth in ACI 301, Chapter 17. Locations of core tests shall be approved by the Engineer. Core sampling and testing shall be at Contractors expense.
 - b. If the results of the core tests indicate that the strength of the structure is inadequate, any replacement, load testing, or strengthening as may be ordered by the Engineer shall be provided by the Contractor without cost to the Authority.
 11. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 12. Correct deficiencies in the Work that test reports and inspections indicate does not comply with the Contract Documents.
- D. Measure floor and slab flatness and levelness according to ASTM E1155 within 48 hours of finishing.
- E. Concrete Finish Measurement and Tolerances
1. All floors are subject to measurement for flatness and levelness and comply with the following:
 - a. Slabs shall be flat within a tolerance of 5/16 inches in 10 feet when tested with a 10 foot long straightedge. Apply straightedge to the slab at 3 foot intervals in both directions, lapping straightedge 3 feet on areas previously checked. Low spots shall not exceed the above dimension anywhere along the straightedge. Flatness shall be checked the next work day after finishing.
 - b. Slabs shall be level within a tolerance of $\pm 1/4$ inch in 10 feet, not to exceed 3/4 inches total variation, anywhere on the floor, from elevations indicated on the Drawings. Levelness shall be checked on a 10 foot grid using a level after removal of forms.
 - c. Measurement Standard: All floors are subject to measurement for flatness and levelness, according to ASTM E1155.
 2. Floor Test Sections
 - a. A floor test section is defined as the smaller of the following areas:
 - 1) The area bounded by column and/or wall lines
 - 2) The area bounded by construction and/or control joint lines
 - 3) Any combination of column lines and/or control joint lines

- b. Test sample measurement lines within each test section shall be multidirectional along 2 orthogonal lines, as defined by ASTM E1155, at a spacing to be determined by the Authority's testing agency.
 - c. The precise layout of each test section shall be determined by the Authority's testing agency.
3. Concrete Floor Finish Tolerance
- a. The following values apply before removal of shores. Levelness values (FL) do not apply to intentionally sloped or cambered areas, nor to slabs poured on metal deck or precast concrete.
 - 1) Slabs

Overall Value FF45/FL30

Minimum Local Value FF30/FL20

4. Floor Elevation Tolerance Envelope
- a. The acceptable tolerance envelope for absolute elevation of any point on the slab surface, with respect to the elevation shown on the Drawings, is as follows:
 - 1) Slab-on-Grade Construction: $\pm \frac{3}{4}$ inch
 - 2) Top surfaces of formed slabs measured prior to removal of supporting shores: $\pm \frac{3}{4}$ inch
 - 3) Top surfaces of all other slabs: $\pm \frac{3}{4}$ inch
 - 4) Slabs specified to slope shall have a tolerance from the specified slope of $\frac{3}{8}$ inch in 10 feet at any point, up to $\frac{3}{4}$ inch from theoretical elevation at any point.

3.5 CLEANING

A. Defective Work

- 1. Imperfect or damaged work or any material damaged or determined to be defective before final completion and acceptance of the entire job shall be satisfactorily replaced at the Contractor's expense, and in conformity with all of the requirements of the Drawings and Specifications.
- 2. Perform removal and replacement of concrete work in such manner as not to impair the appearance or strength of the structure in any way, as approved by the Engineer.

B. Cleaning

- 1. Upon completion of the work remove from the site all forms, equipment, protective coverings and any rubbish resulting therefrom.
- 2. After sweeping floors, wash floors with clean water.
- 3. Leave finished concrete surfaces in a clean condition, satisfactory to the Authority.

END OF SECTION

DIVISION 8
OPENINGS

SECTION 08 71 00 - DOOR HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Commercial door hardware for the following:
 - a. Swinging doors.
 - b. Hinged metal transom.
- B. Related Sections include the following:
 - 1. Division 8 Section "Standard Steel Doors and Frames".
 - 2. Division 8 Section "Fiberglass Reinforced Plastic Doors and Frames".
 - 3. Division 8 Section "Overhead Coiling Doors" for door hardware provided as part of overhead door assemblies.
- C. Products furnished, but not installed, under this Section include the following. Coordinating, purchasing, delivering, and scheduling remain requirements of this Section.
 - 1. Thresholds and weather stripping for locks specified in other Sections.

1.2 SUBMITTALS

- A. Product Data: Include construction and installation details, material descriptions, dimensions of individual components and profiles, and finishes.
- B. Samples for Initial Selection: For each finish, color, and texture required for each type of door hardware indicated.
- C. Samples for Verification: Submit minimum 2-by-4-inch plate Samples of each type of finish required, except primed finish.
- D. Maintenance Data: For each type of door hardware to include in maintenance manuals. Include final hardware and keying schedule.
- E. Warranty: Special warranty specified in this Section.
- F. Other Action Submittals:
 - 1. Door Hardware Sets: Prepared by or under the supervision of Architectural Hardware Consultant, detailing fabrication and assembly of door hardware, as well as procedures and diagrams. Coordinate the final door hardware sets with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
 - a. Format: Comply with scheduling sequence and vertical format in DHI's "Sequence and Format for the Hardware Schedule." Double space entries, and number and date each page.
 - b. Format: Use same scheduling sequence and format and use same door numbers as in the Contract Documents.
 - c. Content: Include the following information:
 - 1) Identification number, location, hand, fire rating and material of each door and frame.
 - 2) Type, style, function, size, quantity, and finish of each door hardware item. Include description and function of each lockset and exit device.
 - 3) Complete designations of every item required for each door or opening including name and manufacturer.
 - 4) Fastenings and other pertinent information.

- 5) Location of each door hardware set, cross-referenced to Drawings, both on floor plans and in door and frame schedule.
 - 6) Explanation of abbreviations, symbols, and codes contained in schedule.
 - 7) Mounting locations for door hardware.
 - 8) Door and frame sizes and materials.
 - 9) List of related door devices specified in other Sections for each door and frame.
- d. Submittal Sequence: Submit the final door hardware sets at earliest possible date, particularly where approval of the door hardware sets must precede fabrication of other work that is critical in Project construction schedule. Include Product Data, Samples, Shop Drawings of other work affected by door hardware, and other information essential to the coordinated review of the door hardware sets.
2. Keying Schedule: Prepared by or under the supervision of Architectural Hardware Consultant, detailing Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by lock manufacturer.
1. Installer's responsibilities include supplying and installing door hardware and providing a qualified Architectural Hardware Consultant available during the course of the Work to consult with Contractor, Engineer, and Owner about door hardware and keying.
 2. Installer shall have warehousing facilities in Project's vicinity.
 3. Scheduling Responsibility: Preparation of door hardware and keying schedules.
- B. Architectural Hardware Consultant Qualifications: A person who is currently certified by DHI as an Architectural Hardware Consultant and who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project.
- C. Source Limitations: Obtain each type and variety of door hardware from a single manufacturer, unless otherwise indicated.
- D. Pre-installation Conference: Conduct conference at Project site.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Inventory door hardware on receipt and provide secure lock-up for door hardware delivered to Project site.
- B. Tag each item or package separately with identification related to the final door hardware sets, and include basic installation instructions, templates, and necessary fasteners with each item or package.
- C. Deliver keys to manufacturer of key control system for subsequent delivery to Owner.

1.5 COORDINATION

- A. Templates: Distribute door hardware templates for doors, frames, and other work specified to be factory prepared for installing door hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including excessive deflection, cracking, or breakage.
 - b. Faulty operation of operators and door hardware.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 - 2. Warranty Period: Three years from date of Substantial Completion, except as follows:
 - a. Exit Devices: Two years from date of Substantial Completion.
 - b. Manual Closers: 10 years from date of Substantial Completion.

1.7 MAINTENANCE SERVICE

- A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

PART 2 - PRODUCTS

2.1 SCHEDULED DOOR HARDWARE

- A. General: Provide door hardware for each door to comply with requirements in this Section and door hardware sets indicated in Part 3 "Door Hardware Sets" Article.
 - 1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and products equivalent in function and comparable in quality to named products.
 - 2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
- B. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of door hardware are indicated in Part 3 "Door Hardware Sets" Article. Products are identified by using door hardware designations, as follows:
 - 1. Named Manufacturers' Products: Manufacturer and product designation are listed for each door hardware type required for the purpose of establishing minimum requirements. Manufacturers' names are abbreviated in Part 3 "Door Hardware Sets" Article.
- C. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified unless noted otherwise in the hardware schedules.

2.2 HINGES, GENERAL

- A. Quantity: Provide the following, unless otherwise indicated:
 - 1. Two Hinges: For doors with heights up to 60 inches.
 - 2. Three Hinges: For doors with heights 61 to 90 inches.
 - 3. Four Hinges: For doors with heights 91 to 120 inches.
 - 4. For doors with heights more than 120 inches provide 4 hinges, plus 1 hinge for every 30 inches of door height greater than 120 inches.
- B. Template Requirements: Provide only template-produced units.

- C. Hinge Weight: Unless otherwise indicated, provide the following:
 - 1. Exterior Doors and interior metal or FRP doors: Heavy-weight hinges.
 - 2. Interior Wood Doors: Standard-weight hinges.
 - 3. Doors with Closers and/or exit devices: Antifriction-bearing hinges – ball bearing.
- D. Hinge Base Metal: Unless otherwise indicated, provide the following:
 - 1. Exterior Hinges: Stainless steel, with stainless-steel pin (630/US32D).
 - 2. Interior Hinges: Stainless steel, with stainless-steel pin (630/US32D).
 - 3. Hinges for Fire-Rated Assemblies: Stainless steel, with stainless-steel pin.
- E. Hinge Size: 4-1/2-inch x 4-1/2-inch, unless otherwise noted.
 - 1. Nonremovable Pins: Provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for outswinging exterior doors.
 - 2. Corners: Square.
- F. Fasteners: Comply with the following:
 - 1. Machine Screws: For metal doors and frames. Install into drilled and tapped holes.
 - 2. Wood Screws: For wood doors.
 - 3. Threaded-to-the-Head Wood Screws: For fire-rated wood doors.
 - 4. Screws: Phillips flat-head. Finish screw heads to match surface of hinges.
 - a. Fasteners for FRP doors and frame hardware are specified in Division 8, "FRP Doors and Frames."

2.3 HINGES

- A. Butts and Hinges: BHMA A156.1. Listed under Category A in BHMA's "Certified Product Directory."
- B. Template Hinge Dimensions: BHMA A156.7.
- C. Available Manufacturers:
 - 1. Hager Companies (HAG).
 - 2. Lawrence Brothers, Inc. (LB).
 - 3. Stanley Commercial Hardware; Div. of The Stanley Works (STH).

2.4 PIVOTS AND PIVOT HINGES

- A. Pivots: BHMA A156.4. Listed under Category C in BHMA's "Certified Product Directory.:
- B. Available Manufacturers:
 - 1. DORMA Architectural Hardware; Member of The DORMA Group North America.
 - 2. IVES Hardware; an Ingersoll-Rand Company.
 - 3. Rixson Specialty Door Controls; an ASSA ABLOY Group company.

2.5 LOCKS AND LATCHES, GENERAL

- A. Accessibility Requirements: Where indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" and ANSI A117.1.
 - 1. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf (22 N).

- B. Latches and Locks for Means of Egress Doors: Comply with NFPA 101. Latches shall not require more than 15 lbf (67 N) to release the latch. Locks shall not require use of a key, tool, or special knowledge for operation.
- C. Lock Trim
 - 1. Levers: Cast.
 - 2. Escutcheons (Roses): Forged or Cast.
 - 3. Dummy Trim: Match lever lock trim and escutcheons.
 - 4. Lockset Designs: Provide lockset design(s) indicated by hardware sets or, if locksets are provided by another manufacturer, provide designs that match those designated.
 - a. Corbin Russwin: ML 2000 Series with Citation CSB (lever) trim.
- D. Lock Throw: Comply with testing requirements for lengths of bolts required for labeled fire doors, and as follows:
 - 1. Mortise Locks: Minimum 3/4-inch latchbolt throw.
 - 2. Deadbolts: Minimum 1-inch bolt throw.
 - a. Bored Locks: Minimum 1/2-inch latchbolt throw.
- E. Backset: 2-3/4 inches, unless otherwise indicated.
- F. Strikes: Manufacturer's standard strike with strike box for each latchbolt or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, and as follows:

2.6 MECHANICAL LOCKS AND LATCHES

- A. Lock Functions: Function numbers and descriptions indicated in door hardware sets comply with the following:
 - 1. Mortise Locks: BHMA A156.13.
 - 2. Bored Locks: BHMA A156.2.
- B. Mortise Locks: Stamped steel case with steel or brass parts; BHMA A156.13, Grade 1; Series 1000.
 - 1. Available Manufacturers:
 - a. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company.
 - b. SARGENT Manufacturing Company; an ASSA ABLOY Group company.
 - c. Yale Commercial Locks and Hardware: an ASSA ABLOY Group Company.
 - 2. Product Reference Standard: Corbin Russwin: ML 2000 Series: 3600 Series (heavy-duty lever locksets).
- C. Bored Locks: BHMA A156.2, Grade 1, Series 4000.
 - 1. Available Manufacturers:
 - a. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company.
 - b. SARGENT Manufacturing Company; an ASSA ABLOY Group company.
 - c. Yale Commercial Locks and Hardware: an ASSA ABLOY Group Company.
 - 2. Product Reference Standard: Corbin Russwin: ML 2000 Series: 3600 Series (heavy-duty lever locksets).

2.7 AUXILIARY LOCKS AND LATCHES

- A. Auxiliary Locks: BHMA A156.5, Grade 1.
 - 1. Available Manufacturers:
 - a. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company.
 - b. SARGENT Manufacturing Company; an ASSA ABLOY Group company.
 - c. Yale Commercial Locks and Hardware: an ASSA ABLOY Group Company.

2.8 DOOR BOLTS

- A. Bolt Throws: Comply with testing requirements for length of bolts required for labeled fire doors, and as follows:
 - 1. Mortise Flush Bolts: Minimum 3/4-inch (19 mm) throw.
 - 2. Surface Bolts: Minimum 7/8-inch (22 mm) throw.
 - 3. Fire-Rated Surface Bolts: Minimum 1-inch (25 mm) throw.
- B. Dustproof Strikes: BHMA A156.16, Grade 1.
- C. Surface Bolts: BHMA A156.16, Grade 1.
 - 1. Flush Bolt Heads: Minimum of 1/2-inch (13 mm) diameter rods of stainless steel with minimum 12-inch heads (305 mm) long rods for doors up to 84 inches (2134 mm) in height. Provide longer rods as necessary for doors exceeding 84 inches (2134 mm).
 - 2. Available Manufacturers:
 - a. IVES Hardware, an Ingersoll-Rand Company.
 - b. Other approved equal.
- D. Manual Flush Bolts: BHMA A156.16, Grade 1, designed for mortising into door edge.
 - 1. Available Manufacturers:
 - a. IVES Hardware; an Ingersoll-Rand Company.
 - b. Stanley Commercial Hardware; Div. of The Stanley Works.
 - c. Trimco.
 - 2. Product Reference Standard: Ives No. 457-1/2 x 12 inches with top and bottom plates for rod retention.

2.9 EXIT DEVICES

- A. Exit Devices: BHMA A156.3, Grade 1.
- B. Accessibility Requirements: Where handles, pulls, latches, locks, and other operating devices are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" and ANSI A117.1.
 - 1. Provide operating devices that do not require tight grasping, pinching or twisting of the wrist and that operate with a force of not more than 5 lbf.
- C. Exit Devices for Means of Egress Doors: Comply with NFPA 101. Exit devices shall not require more than 15 lbf to release the latch. Locks shall not require use of a key, tool, or special knowledge for operation.
- D. Panic Exit Devices: Listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for panic protection, based on testing according to UL 305.
- E. Fire Exit Devices: Devices complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire and panic protection, based on testing according to UL 305 and NFPA 252.
- F. Exit Device Design: Push Bar type equal to Corbin Russwin ED 5000 Series.
 - 1. Mortise lock exit devices: Corbin Russwin Series ED 5600L, with Citation C7M Lever handle) trim.
 - 2. Rim exit device: Corbin Russwin Series ED 5200 Series with Citation C7M trim.
- G. Outside Trim: Lever, Lever with Mortise cylinder or Pull with Mortise cylinder; material and finish to match locksets, unless otherwise indicated.

1. Match design for locksets and latchsets, unless otherwise indicated.

H. Dogging: One point dogging with 1/4-turn maximum to activate.

2.10 LOCK CYLINDERS

A. Standard Lock Cylinders: BHMA A156.5, Grade 1.

1. Key Control Level: Category A.
2. Destructive Test Level: Category A.
3. Surreptitious Entry Resistance Level: Category A.

B. Cylinders: Manufacturer's standard tumbler type, constructed from brass or bronze, stainless steel, or nickel silver, and complying with the following:

1. Number of Pins: Six.
2. Mortise Type: Threaded cylinders with rings and straight- or clover-type cam.
3. Rim Type: Cylinders with back plate, flat-type vertical or horizontal tailpiece, and raised trim ring.
4. Bored-Lock Type: Cylinders with tailpieces to suit locks.

C. Permanent Cores: Manufacturer's standard; finish face to match lockset; complying with the following:

1. Interchangeable Cores: Core insert, removable by use of a special key; usable with other manufacturers' cylinders.

D. Construction Keying: Comply with the following:

1. Construction Cores: Provide construction cores that are replaceable by permanent cores. Provide 10 construction master keys.
 - a. Replace construction cores with permanent cores as indicated in keying schedule.

E. Manufacturer: Same manufacturer as for locks and latches.

F. Available Manufacturers

1. Corbin Russwin Architectural Hardware; an ASSA ABLOY Group company (CR).

2.11 CLOSERS

A. Accessibility Requirements: Where handles, pulls, latches, locks, and other operating devices are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" and ANSI A117.1.

1. Comply with the following maximum opening-force requirements:
 - a. Interior, Non-Fire-Rated Hinged Doors: 5 lbf (22.2 N) applied perpendicular to door.
 - b. Fire Doors: Minimum opening force allowable by authorities having jurisdiction.

B. Door Closers for Means of Egress Doors: Comply with NFPA 101. Door closers shall not require more than 30 lbf (133 N) to set door in motion and not more than 15 lbf (67 N) to open door to minimum required width.

C. Overhead Closers: Closers shall have high-strength cast-iron body with rectangular covers, adjustable spring power and back-check, and full rack and pinion action. All closers shall have adjustable back-check intensity valves and separate adjustment screws for closing and latching speeds.

1. Closers for doors over 7-feet in height, or more than 3-feet wide, shall have heavy duty arms.

2. Closers at exterior doors shall include positive stop arms unless otherwise indicated.
 3. Door closer covers and arms shall be spray painted to match door hardware.
 4. Closers shall be provided with hex bolts for fastening through doors, frames and transoms.
- D. Size of Units: Unless otherwise indicated, comply with manufacturer's written recommendations for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.
- E. Surface Closers: BHMA A156.4, Grade 1. Listed under Category C in BHMA's "Certified Product Directory." Provide type of arm required for closer to be located on non-public side of door, unless otherwise indicated.
- F. Closer Design/Type: Closer type as follows:
1. Regular Arm: Corbin Russwin DC 2200 Series
 2. Parallel Arm: Corbin Russwin DC 2200 Series
 3. Parallel Arm with Positive Stop: Corbin Russwin DC 2210
 - a. Multi-size application

2.12 PROTECTIVE DOOR PLATES

- A. Size: 1-1/2 inches (38 mm) less than door width on push side and 1/2 inch (13 mm) less than door width on pull side, by height specified below.
- B. Fasteners: Manufacturer's standard machine or self-tapping screws.
- C. Metal Protective Kick Plates: BHMA A156.6; beveled top and 2 sides; fabricated from the following material:
1. Material: 0.050-inch- (1.3 mm) thick stainless steel.
 2. Product References Standard: Rockwood No. 1050; 16 inches high.
- D. Metal Protective Armor Plates: Beveled top and two sides.
1. Material: 0.062 inch thick stainless steel.
 2. Product Reference Standard: Rockwood No. 1050; 30 inches high.

2.13 STOPS AND HOLDERS

- A. Stops and Bumpers: General: BHMA A156.16, Grade 1.
1. Provide wall stops for doors unless other type stops are scheduled or indicated. Do not mount floor stops where they will impede pedestrian or vehicular traffic. Where floor or wall stops are not appropriate, provide overhead holders.
- B. Door Stops: Door stops shall be of the type specified in the hardware sets or in this schedule, and shall be provided with the proper fasteners.
1. Door Stop Schedule

	Floor Stop w/Holder	Floor Stop Dome	Wall Stop w/Holder	Wall Stop	Kick Stop (4" Arm)
IVES	446/450	438	445/449	407-1/2	452

2. Fasteners/Anchors: Stops shall be provided with machine screws and anchors at concrete and masonry conditions, and toggle bolts at plaster, gypsum board, and wood conditions.

- C. Overhead Holders: Overhead type door holders shall be concealed type of correct size for door, 90 degrees openable, unless 120 degree opening shown, and allowing for checkmating. Interior doors shall be provided with overhead stops if wall type stops cannot be used and floor stops create a tripping hazard. Finish shall be chrome plated bronze with satin finish, US 26D, unless otherwise specified.
 - 1. Holders Design: Door holders shall be Russwin Corbin, DH 5000 Series, Holder No. DH5400, or equal.
- D. Silencers for Metal Door Frames: BHMA A156.16, Grade 1; neoprene or rubber, minimum diameter 1/2 inch (13 mm); fabricated for drilled-in application to frame.

2.14 THRESHOLDS

- A. Standard: BHMA A156.21. Listed under Category J in BHMA's "Certified Product Directory."
- B. Accessibility Requirements: Where thresholds are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" and ANSI A117.1.
 - 1. Bevel raised thresholds with a slope of not more than 1:2. Provide thresholds not more than 1/2-inch.
- C. Thresholds for Means of Egress Doors: Comply with NFPA 101. Maximum 1/2-inch (13 mm) high.
- D. Threshold Design: All exterior doors shall receive a panic style (offset) aluminum threshold unless otherwise indicated:
 - 1. Accessible Entry: National Guard No. 896N (neoprene gasket).
 - 2. Non-Accessible Entry: National Guard No. 884N (neoprene gasket).
 - 3. Receiving Entry: National Guard No. 513, Saddle/flat style threshold.

2.15 MISCELLANEOUS DOOR HARDWARE/ACCESSORIES

- A. Push Plates and Pulls: 4-inch by 16-inch by 0.050 thick, stainless steel: Rockwood #70 or equal. Pulls shall be 3/4" diameter thru-bolted with 4-inch x 16-inch stainless steel plate, Rockwood No. 105 X 70, or equal.
- B. Astragal: "T" Astragal No. 158NA, National Guard Products.
- C. Coordinator: Frame mounted, non-handed coordinator and filler piece; Rockwood No. 1600 Series x US26D.
Provide Rockwood No. 1100 carry bars at openings with astragals.
- D. Drip Cap: Door Top: National Guard No. 16AD x door width plus 2 inches. Mount head to hollow metal frame.
- E. Bottom Sweep: National Guard No. 201NA x door width.
- F. Weatherstrip: National Guard No. 135N; install at each jamb and at head.
- G. Cane Bolt: Heavy-duty cane bolt, Hager No. 1408; 18 inches long x 5/8-inch diameter x US32D (with bolt guides, keeper, and surface strikeplate).
 - 1. Finish: Galvanized or factory paint finish.

- H. Exit Devices: Sargent 8800 (Rim) Series with maximum corrosion-resistant design and finishes, i.e., US32D x CPC. Provide fire-rated devices as noted on Door Schedules. All devices must be keyed to Corbin Russwin system.
- I. Closers: LCN 4041-EDA-SRI-ALXTB; provide with standard color powder coat paint finish.
- J. Push-Pulls: Rockwood No. 107 x 70 x US32D.
- K. Kick Plates: Rockwood No. 1050; 16 inches high x 2 inches less than door width x 0.050 inch thick x US32D.
- L. Armor Plates: Rockwood No. 1050; 30 inches high x 2 inches less than door width x 0.062 inch thick x US32D (with bevel at three sides).
- M. Cane Bolt: Heavy-duty cane bolt, Hager No. 1408; 18 inches long x 5/8-inch diameter x US32D (with bolt guides, keeper, and surface strikeplate).
 - 1. Finish: Galvanized or custom applied powder coat paint.
- N. Astragal: FRP astragal by door manufacturer; furnish with neoprene weatherstrip seal.
- O. Threshold: FRP offset threshold by door manufacturer; furnish with neoprene weatherstripping at offset face to form a “weatherseal.”
- P. Panic Exit Devices: Devices complying with NFPA 80 and as further specified in Section 2.9.

2.16 KEYING

- A. Keying System: Factory registered, complying with guidelines in BHMA A156.28, Appendix A.
 - 1. Existing System: Master key locks to Owner’s existing system.
- B. Keys: Nickel silver.
 - 1. Quantity: In addition to one extra key blank for each lock, provide the following:
 - a. Master Keys: Five.

2.17 FABRICATION

- A. Manufacturer’s Nameplate: Do not provide products that have manufacturer’s name or trade name displayed in a visible location.
 - 1. Manufacturer’s identification is permitted on rim of lock cylinders only.
- B. Base Metals: Produce door hardware units of base metal, fabricated by forming method indicated, using manufacturer’s standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18. Do not furnish manufacturer’s standard materials or forming methods if different from specified standard.
- C. Fasteners: Provide door hardware manufactured to comply with published templates generally prepared for machine, wood, and sheet metal screws. Provide screws according to commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.
 - 1. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only

means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.

2. Steel Machine or Wood Screws: For the following fire-rated applications:
 - a. Mortise hinges to doors.
 - b. Strike plates to frames.
 - c. Closers to doors and frames.
3. Steel Through Bolts: For the following fire-rated applications unless door blocking is provided:
 - a. Surface hinges to doors.
 - b. Closers to doors and frames.
 - c. Surface-mounted exit devices.
4. Spacers or Sex Bolts: For through bolting of hollow-metal doors.
5. Fasteners for Wood Doors: Comply with requirements in DHI WDHS.2, "Recommended Fasteners for Wood Doors."

2.18 FINISHES

- A. Standard: BHMA A156.18, as indicated in door hardware sets.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable temporary protective cover before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.19 MANUFACTURERS

- A. Product numbers listed in the following specifications are taken from catalogs of manufacturers listed as follows:
 1. ST Stanley Hardware
 2. S Sargent & Company
 3. NG National Guard Products
 4. R Russwin
 5. Mc McKinney
 6. N Norton
 7. H Hager
 8. RO Rockwood Mfg.
 9. I Ives
 10. GJ Glynn Johnson
 11. SchSchlage
 12. VD Von Duprin
- B. Products of the following manufacturers will be considered acceptable provided products are of equivalent weight, function, materials and design:
 1. Hinges: Hager, Mc Kinney
 2. Locks: Russwin, Sargent, Schlage
 3. Closers: Russwin, Norton, Sargent
 4. Holders and Stops: Sargent
 5. Door Trim: Glynn Johnson, Ives
 6. Thresholds & Weatherstripping National Guard

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, wall and floor construction, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Steel Doors and Frames: Comply with DHI A115 Series.
 - 1. Surface-Applied Door Hardware: Drill and tap doors and frames according to ANSI A250.6.

3.3 INSTALLATION

- A. Mounting Heights: Mount door hardware units at heights indicated as follows unless otherwise indicated or required to comply with governing regulations.
 - 1. Standard Steel Doors and Frames: DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
 - 2. Custom Steel Doors and Frames: DHI's "Recommended Locations for Builders' Hardware for Custom Steel Doors and Frames."
- B. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 9 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.
 - 1. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
 - 2. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
- C. Thresholds: Set thresholds for exterior doors in full bed of sealant complying with requirements specified in Division 7 Section "Joint Sealants."

3.4 ADJUSTING

- A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
 - 1. Door Closers: Unless otherwise required by authorities having jurisdiction, adjust sweep period so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.

3.5 CLEANING AND PROTECTION

- A. Clean adjacent surfaces soiled by door hardware installation.
- B. Clean operating items as necessary to restore proper function and finish.
- C. Provide final protection and maintain conditions that ensure that door hardware is without damage or deterioration at time of Substantial Completion.

3.6 DOOR HARDWARE SETS

- A. In addition to miscellaneous hardware per section 2.15 provide:

HARDWARE SET 1 (HW-1)		
EACH TO HAVE		
Mc	3 Hinges	TB 2714 4 ½ X 4 ½ US26D NRP
VD	Rim Exit	98L X US26D W/Schlage 20-022X26D 35-101-C
S	Closer	1431-OU EN
RO	Kickplate	10" X 34" K1050F US32D
RO	Kick Down Door Stop	461L US26D
NG	1 Threshold	884V x Length Required
NG	1 Seal	5050B-17 x Length Required
	Lock	

END OF SECTION

DIVISION 9
FINISHES

SECTION 09 90 00 - PAINTING AND PROTECTIVE COATINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Exposed, buried, and submerged metal, exposed PVC and CPVC, exposed FRP, and aluminum and dissimilar metals, to be protective painted, whether specifically mentioned or not, except as specified otherwise. Prime coat structural steel surfaces. Exterior concrete surfaces will not be protective painted unless specifically indicated. Interior concrete surfaces will be protective painted as specified herein.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. D 16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
 - b. D 4541 - Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers.
 2. NACE International (NACE):
 - a. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
 - b. SP0188-06 - Discontinuity (Holiday) Testing of Protective Coatings.
 3. National Association of Pipe Fabricators (NAPF):
 - a. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.
 4. NSF International (NSF):
 - a. 61 - Drinking Water System Components - Health Effects.
 5. Society for Protective Coatings (SSPC):
 - a. QP1, Standard Procedure for Evaluating Qualifications of Painting Contractors.
 - b. QP2, Standard Procedure for Evaluating the Qualifications of Painting Contractors to Remove Hazardous Paint.
 - c. SP COM - Surface Preparation Commentary for Steel and Concrete Substrates.
 - d. SP-1 - Solvent Cleaning.
 - e. SP-2 - Hand Tool Cleaning.
 - f. SP-3 - Power Tool Cleaning.
 - g. SP-5 - White Metal Blast Cleaning.
 - h. SP-6 - Commercial Blast Cleaning.
 - i. SP-7 - Brush-Off Blast Cleaning.
 - j. SP 8, Pickling.
 - k. SP-10 - Near-White Blast Cleaning.
 - l. SP 11-T, Power Tool Cleaning to Bare Metal.
 - m. SP 13, Surface Preparation of Concrete.
 - n. Guide No. 3, PA, Guide to Safety in Painting Applications.
 6. U.S. Environment Protection Agency (EPA):
 - a. Method 24 - Surface Coatings.
 7. NACE International (NACE):
 - a. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
 - b. SP0188-06 - Discontinuity (Holiday) Testing of Protective Coatings.
 8. National Association of Pipe Fabricators (NAPF):
 - a. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.
 9. NSF International (NSF):
 - a. 61 - Drinking Water System Components - Health Effects.

10. Society for Protective Coatings (SSPC):
 - a. QP1, Standard Procedure for Evaluating Qualifications of Painting Contractors.
 - b. QP2, Standard Procedure for Evaluating the Qualifications of Painting Contractors to Remove Hazardous Paint.
 - c. SP COM - Surface Preparation Commentary for Steel and Concrete Substrates.
 - d. SP-1 - Solvent Cleaning.
 - e. SP-2 - Hand Tool Cleaning.
 - f. SP-3 - Power Tool Cleaning.
 - g. SP-5 - White Metal Blast Cleaning.
 - h. SP-6 - Commercial Blast Cleaning.
 - i. SP-7 – Brush-Off Blast Cleaning.
 - j. SP 8, Pickling.
 - k. SP-10 – Near-White Blast Cleaning.
 - l. SP 11-T, Power Tool Cleaning to Bare Metal.
 - m. SP 13, Surface Preparation of Concrete.
 - n. Guide No. 3, PA, Guide to Safety in Painting Applications.
11. U.S. Environment Protection Agency (EPA):
 - a. Method 24 - Surface Coatings.

1.3 DEFINITIONS

- A. Terms used in this section:
 1. Submerged metal: Steel or iron surfaces below tops of channel or structure walls which will contain water even when above expected water level.
 2. Submerged concrete and masonry surfaces: Surfaces which are or will be:
 3. Underwater.
 4. In structures which normally contain water.
 5. Below tops of walls of water containing structures.
 6. Exposed surface: Any metal or concrete surface, indoors or outdoors that is exposed to view.
 7. Dry film thickness (DFT): Thickness of fully cured coating, measured in mils.
 8. Volatile organic compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon, as determined by EPA Method 24.
 9. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
 10. Where SSPC surface preparation standards are specified or implied for ductile iron pipe or fittings, the equivalent NAPF surface preparation standard shall be substituted for the SSPC standard.
 11. Coverage: Total minimum dry film thickness in mils, or square feet per gallon.
 12. FRP: Fiberglass Reinforced Plastic.
 13. HCl: Hydrochloric Acid.
 14. MDFT: Minimum Dry Film Thickness.
 15. MDFTPC: Minimum Dry Film Thickness per Coat.
 16. Mil: Thousandth of an inch.
 17. Military Specification-Paint.
 18. PSDS: Paint System Data Sheet.
 19. SFPG: Square Feet per Gallon.
 20. SFPGPC: Square Feet per Gallon per Coat.
 21. SP: Surface Preparation.

1.4 PERFORMANCE REQUIREMENTS

- A. Coating materials shall be especially adapted for use in water facilities.
- B. Coating materials used in contact with potable water supply systems shall be certified to NSF 61.

1.5 SUBMITTALS

- A. General: Submit in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.
- B. Shop Drawings:
 - 1. Schedule of proposed coating materials.
 - 2. Schedule of surfaces to be coated with each coating material.
- C. Product Data: Include description of physical properties of coatings including solids content and ingredient analysis, VOC content, temperature resistance, typical exposures and limitations, and manufacturer's standard color chips:
 - 1. Data Sheets:
 - a. For each paint system, furnish a Paint System Data Sheet (PSDS), the Manufacturer's Technical Data Sheets, and paint colors available (where applicable) for each product used in the paint system. The PSDS form is appended to the end of this section.
 - b. Submit required information on a system-by-system basis.
 - c. Furnish copies of paint system submittals to the coating applicator.
 - d. Indiscriminate submittal of Manufacturer's literature only is not acceptable.
 - e. Regulatory requirements: Submit data concerning the following:
 - f. Volatile organic compound limitations.
 - g. Coatings containing lead compounds and PCBs.
 - h. Abrasives and abrasive blast cleaning techniques, and disposal.
 - i. NSF certification of coatings for use in potable water supply systems.
- D. Samples: Include 8-inch square drawdowns or brush-outs of topcoat finish when requested. Identify each sample as to finish, formula, color name and number and sheen name and gloss units.
- E. Certificates: Submit in accordance with requirements for Product Data.
- F. Manufacturer's Instructions: Include the following:
 - 1. Special requirements for transportation and storage.
 - 2. Mixing instructions.
 - 3. Shelf life.
 - 4. Pot life of material.
 - 5. Precautions for applications free of defects.
 - 6. Surface preparation.
 - 7. Method of application.
 - 8. Recommended number of coats.
 - 9. Recommended dry film thickness (DFT) of each coat.
 - 10. Recommended total dry film thickness (DFT).
 - 11. Drying time of each coat, including prime coat.
 - 12. Required prime coat.
 - 13. Compatible and non-compatible prime coats.
 - 14. Recommended thinners, when recommended.
 - 15. Limits of ambient conditions during and after application.
 - 16. Time allowed between coats (minimum and maximum).
 - 17. Required protection from sun, wind, and other conditions.
 - 18. Touch-up requirements and limitations.
 - 19. Minimum adhesion of each system submitted in accordance with ASTM D 4541.
- G. Manufacturer's Representative's Field Reports.
- H. Operations and Maintenance Data: Submit as specified in Section 01 77 00 CLOSEOUT PROCEDURES.

1. Reports on visits to project site to view and approve surface preparation of structures to be coated.
2. Reports on visits to project site to observe and approve coating application procedures.
3. Reports on visits to coating plants to observe and approve surface preparation and coating application on items that are "shop coated."

1.6 QUALITY ASSURANCE

- A. Quality Assurance Submittals:
1. Quality Assurance plan.
 2. Qualifications of coating applicator including List of Similar Projects and List of References substantiating experience.
 3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
 4. If the Manufacturer of finish coating differs from that of shop primer, provide both Manufacturers' written confirmation that materials are compatible.
 5. Manufacturer's written instructions and special details for applying each type of paint.
 6. Manufacturers' Certification of Proper Installation.
- B. Certifications: All paints and coatings to be used on this project comply with current federal, state, and local VOC regulations
- C. Applicator qualifications:
1. Minimum of 5 years' experience applying specified type or types of coatings under conditions similar to those of the Work:
 2. Provide qualifications of applicator and references listing 5 similar projects completed in the past 2 years.
 3. Manufacturer approved applicator when manufacturer has approved applicator program.
 4. Approved and licensed by polymorphic polyester resin manufacturer to apply polymorphic polyester resin coating system.
 5. Approved and licensed by elastomeric polyurethane (100 percent solids) manufacturer to apply 100 percent solids elastomeric polyurethane system.
 6. Applicator of off-site application of coal tar epoxy shall have successfully applied coal tar epoxy on similar surfaces in material, size, and complexity as on the Project.
- D. Regulatory requirements: Comply with governing agencies regulations by using coatings that do not exceed permissible volatile organic compound limits and do not contain lead:
1. Do not use coal tar epoxy in contact with drinking water or exposed to ultraviolet radiation.
 2. Perform surface preparation and painting in accordance with recommendations of the following:
 3. Paint Manufacturer's instructions.
 4. SSPC-PA Guide No. 3, Guide to Safety in Paint Applications.
 5. Federal, state, and local agencies having jurisdiction.
- E. Samples:
1. Reference Panel:
 - a. Prior to start of surface preparation, furnish a 4" by 4" steel panel for each grade of sandblast specified herein, prepared to specified requirements.
 - b. Provide panel representative of the steel used; prevent deterioration of surface quality.
 - c. Upon approval of Engineer, panel to be reference source for inspection.
 - d. Unless otherwise specified, before painting work is started, prepare minimum 8" by 10" samples with type of paint and application specified on similar substrate to which paint is to be applied.
 - e. Furnish additional samples as required until colors, finishes, and textures are approved.

- f. Approved samples to be the quality standard for final finishes.
- g. Field samples:
- h. Prepare and coat a minimum 100 square foot area between corners or limits such as control or construction joints of each system.
- i. Approved field sample may be part of Work.
- j. Obtain approval before painting other surfaces.

F. Pre-installation conference: Conduct as specified in Section 01 31 19 PROJECT MEETINGS.

G. Compatibility of coatings: Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

H. Services of coating manufacturer's representative: Arrange for coating manufacturer's representative to attend pre-installation conferences. Make periodic visits to the project site to provide consultation and inspection services during surface preparation and application of coatings, and to make visits to coating plants to observe and approve surface preparation procedures and coating application of items to be "shop primed and coated".

I. Contract Closeout Submittals: Special guarantee.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle products as required by manufacturer and elsewhere in these Specifications.

B. Remove unspecified and unapproved paints from Project site immediately.

C. Deliver new unopened containers with labels identifying the manufacturer's name, brand name, product type, batch number, date of manufacturer, expiration date or shelf life, color, and mixing and reducing instructions.

- 1. Do not deliver materials aged more than 12 months from manufacturing date.

D. Store coatings in well-ventilated facility that provides protection from the sun, weather, and fire hazards. Maintain ambient storage temperature between 45 and 90 degrees Fahrenheit, unless otherwise recommended by the manufacturer.

E. Take precautions to prevent fire and spontaneous combustion.

F. Shipping:

- 1. Where pre-coated items are to be shipped to the site, protect coating from damage. Batten coated items to prevent abrasion.
- 2. Use nonmetallic or padded slings and straps in handling.

1.8 PROJECT CONDITIONS

A. Surface moisture contents: Do not coat surfaces that exceed manufacturer specified moisture contents, or when not specified by the manufacturer, the following moisture contents:

- 1. Plaster and gypsum wallboard: 12 percent.
- 2. Masonry, concrete, and concrete block: 12 percent.
- 3. Interior located wood: 15 percent.
- 4. Concrete floors: 7 percent.

B. Do not apply coatings:

- 1. Under dusty conditions or adverse environmental conditions, unless tenting, covers, or other such protection is provided for structures to be coated.

2. When light on surfaces measures less than 15 foot-candles.
 3. When ambient or surface temperature is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
 4. When relative humidity is higher than 85 percent.
 5. When surface temperature is less than 5 degrees Fahrenheit above dew point.
 6. When surface temperature exceeds the manufacturer's recommendation.
 7. When ambient temperature exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
 8. Apply clear finishes at minimum 65 degrees Fahrenheit.
- C. Provide fans, heating devices, dehumidifiers, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.
- D. Provide adequate continuous ventilation and sufficient heating facilities to maintain minimum 55 degrees Fahrenheit for 24 hours before, during and 48 hours after application of finishes.
- E. Dehumidification and heating for coating of digester interiors, wet wells, and high humidity enclosed spaces:
1. Provide dehumidification and heating of digester interior spaces in which surface preparation, coating application, or curing is in progress according to the following schedule:
 - a. October 1 to April 30: Provide continuous dehumidification and heating as required to maintain the tanks within environmental ranges as specified in this Section and as recommended by the coating material manufacturer. For the purposes of this Section, "continuous" is defined as 24 hours per day and 7 days per week.
 - b. May 1 to September 30: Provide temporary dehumidification and heating as may be required to maintain the tanks within the specified environmental ranges in the event of adverse weather or other temporary condition. At CONTRACTOR's option and at his sole expense, CONTRACTOR may suspend work until such time as acceptable environmental conditions are restored, in lieu of temporary dehumidification and heating. Repair or replace any coating or surface preparation damaged by suspension of work, at CONTRACTOR's sole expense.
 2. Equipment requirements:
 - a. Capacity: Provide dehumidification, heating, and air circulation equipment with minimum capacity to perform the following:

Maintain the dew point of the air in the tanks at a temperature at least 5 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is underway.

Reduce dew point temperature of the air in the tanks by at least 10 degrees Fahrenheit in 20 minutes.

Maintain air temperature in the tanks at 60 degrees minimum.

b. Systems:

Internal combustion engine generators: May be used; CONTRACTOR shall obtain all required permits and provide air pollution and noise control devices on equipment as required by permitting agencies.]

Dehumidification: Provide desiccant or refrigeration drying. Desiccant types shall have a rotary desiccant wheel capable of continuous operation. No Liquid, granular, or loose lithium chloride drying systems will be allowed.

Heating: Electric, indirect combustion, or steam coil methods may be used. Direct fired combustion heaters will not be allowed during abrasive blasting, coating application, or coating cure time.

3. Design and submittals:

- a. CONTRACTOR shall prepare dehumidification and heating plan for this project, including all equipment and operating procedures.
- b. Suppliers of services and equipment shall have not less than 3 years' experience in similar applications.
- c. Supplier: The following or equal:

Cargocaire Corporation (Munters) or equal.

- d. Submit dehumidification and heating plan for ENGINEER's review.

4. Monitoring and performance:
 - a. Measure and record relative humidity and temperature of air, and structure temperature twice daily (beginning and end of work shifts) to verify that proper humidity and temperature levels are achieved inside the work area after the dehumidification equipment is installed and operational. Test results shall be made available to the ENGINEER upon request.
 - b. Interior space of the working area and tank(s) shall be sealed and a slight positive pressure maintained as recommended by the supplier of the dehumidification equipment.
 - c. The filtration system used to remove dust from the air shall be designed so that it does not interfere with the dehumidification equipment's ability to control the dew point and relative humidity inside the reservoir.

The air from the tank, working area, or dust filtration equipment shall not be recirculated through the dehumidifier during coating application or when solvent vapors are present.

1.9 SEQUENCING AND SCHEDULING

- A. Sequence and Schedule: As specified in Section 01 14 00 WORK RESTRICTIONS.

1.10 SPECIAL GUARANTEE

- A. Furnish Manufacturer's extended guarantee or warranty, with OWNER named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the OWNER, removal and replacement of work specified in this Specification section found *defective* during a period of 1 year after the date of Substantial Completion.
- B. Contractor and paint Manufacturer shall jointly and severally furnish guarantee.

1.11 MAINTENANCE

- A. Include minimum 1 gallon of each type and color of coating applied:
 1. When manufacturer packages material in gallon cans, deliver unopened labeled cans as comes from factory.
 2. When manufacturer does not package material in gallon cans, deliver material in new gallon containers, properly sealed and identified with typed labels indicating brand, type, and color.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Special coatings: One of the following or equal:
 1. Carboline: Carboline, St. Louis, MO.
 2. Ceilcote: International Protective Coatings, Berea, OH.
 3. Dampney: The Dampney Company, Everett, MA.
 4. Devoe: International Protective Coatings, Louisville, KY.
 5. Dudick: Dudick, Inc., Streetsboro, OH.
 6. GET: Global Eco Technologies, Pittsburg, CA.
 7. Henkel: Henkel North America, Madison Heights MI.
 8. IET: Integrated Environmental Technologies, Santa Barbara, CA.
 9. Induron Protective Coatings, Birmingham, AL.
 10. PPG Amercoat: PPG Protective & Marine Coatings, Brea, CA.
 11. Raven Lining Systems, Broken Arrow, OK.
 12. Rustoluem : Rustoleum Corp., Sommerset, NJ.
 13. Sanchem: Sanchem, Chicago, IL.

14. Superior: Superior Environmental Products, Inc., Addison, TX.
15. S-W: Sherwin-Williams Co., Cleveland, OH.
16. Tnemec: Tnemec Co., Kansas City, MO.
17. Wasser: Wasser High Tech Coatings, Kent, WA.
18. ZRC: ZRC Worldwide Innovative Zinc Technologies, Marshfield, MA.

2.2 PREPARATION AND PRETREATMENT MATERIALS

- A. Metal pretreatment: As manufactured by one of the following or equal:
 1. Henkel: Galvaprep 5.
 2. International: AWLGrip Alumiprep 33.
- B. Surface cleaner and degreaser: As manufactured by one of the following or equal:
 1. Carboline Surface Cleaner No.3.
 2. Devoe: Devprep 88.
 3. S-W: Clean and Etch.

2.3 COATING MATERIALS

- A. Alkali resistant bitumastic: As manufactured by one of the following or equal:
 1. Carboline: Bitumastic No. 50.
 2. S-W: Targuard.
 3. Wasser: MC-Tar.
- B. Wax coating: As manufactured by the following or equal:
 1. Sanchem: No-Ox-Id A special.
- C. High solids epoxy (self-priming) not less than 72 percent solids by volume: As manufactured by one of the following or equal:
 1. Carboline: Carboguard 891.
 2. Devoe: Bar Rust 233H.
 3. Induron: PE-70
 4. PPG Amercoat: Amerlock 2.
 5. S-W: Macropoxy 646.
- D. Aliphatic or aliphatic-acrylic polyurethane: As manufactured by one of the following or equal:
 1. Carboline: Carbothane 134 VOC.
 2. Devoe: Devthane 379.
 3. PPG Amercoat: Amershield VOC.
 4. S-W: High Solids Polyurethane [CA].
 5. Tnemec: Endura-Shield II Series 1075 (U).
- E. Epoxy Novolac: Multi-component aggregate-filled epoxy system specifically designed for exposure to municipal wastewater. As manufactured by one of the following or equal:
 1. Sauereisen: Sewergard No. 210, 210S, or 210GL
 2. Carboline: Plasite 4550 S
 3. Devoe: Devmat 100
 4. Raven 410
- F. High temperature coating 150 to 350 degrees Fahrenheit: As manufactured by one of the following or equal:
 1. Carboline: Thermaline 4900.
 2. Dampney: Thermalox 245 Silicone - Zinc Dust.
 3. PPG Amercoat: Amerlock 2/400 GFK.

- G. High temperature coating 400 to 1,000 degrees Fahrenheit (dry): As manufactured by one of the following or equal:
 - 1. Carboline: Thermaline 4700.
 - 2. Dampney: Thermolox 230C Series Silicone.
 - 3. Devoe: HT-12, High Heat Silicone.
 - H. High temperature coating up to 1,400 degrees Fahrenheit: As manufactured by the following or equal:
 - 1. Dampney: Thermalox 240 Silicone Ceramix.
 - I. Asphalt varnish: AWWA C 500.
 - J. Protective coal tar: As manufactured by one of the following or equal:
 - 1. Carboline: Bitumastic No. 50.
 - 2. PPG Amercoat: 78HB
 - K. Coal tar epoxy: As manufactured by one of the following or equal:
 - 1. Carboline: 300-M, Bitumastic.
 - 2. PPG Amercoat: 78HB.
 - 3. S-W: Tar Guard 100.
 - 4. Tnemec: Series 46H-413.
 - L. Coal tar epoxy substitute: As manufactured by one of the following or equal:
 - 1. Devoe: Devtar 5A HS.
 - 2. S-W: Macropoxy 646 Black.
 - M. Vinyl ester: Glass mat reinforced, total system 125 mils DFT. As manufactured by one of the following or equal:
 - 1. Carboline: Semstone 870.
 - 2. Ceilcote: 6640 Ceilcrete.
 - 3. Dudick: Protecto-Flex 800.
 - 4. Tnemec: Chembloc Series 239SC.
 - N. Elastomeric polyurethane, 100 percent solids, ASTM D 16, Type V, (Urethane P): As manufactured by the following or equal:
 - 1. GET: Endura-Flex EF-1988.
 - O. Concrete floor coatings: As manufactured by one of the following or equal:
 - 1. Carboline: Semstone 140SL.
 - 2. Devoe: Devran 124.
 - 3. Dudick: Polymer Alloy 1000.
 - 4. Tnemec: Tneme-Glaze Series 282.
 - P. Waterborne acrylic emulsion: As manufactured by one of the following or equal:
 - 1. S-W: DTM Acrylic B66W1.
 - 2. Tnemec: Tneme-Cryl Series 6.
 - Q. Galvanizing Zinc Compound: As manufactured by one of the following or equal:
 - 1. ZRC: Cold Galvanizing Compound.
- 2.4 MIXES
- A. Mix in accordance with manufacturer's instructions.

PART 3 - EXECUTION

3.1 GENERAL PROTECTION

- A. Protect adjacent surfaces from coatings and damage. Repair damage resulting from inadequate or unsuitable protection:
- B. Protect adjacent surfaces not to be coated from spatter and droppings with drop cloths and other coverings:
 - 1. Mask off surfaces of items not to be coated or remove items from area.
- C. Furnish sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and in particular, surfaces within storage and preparation area.
- D. Place cotton waste, cloths, and material which may constitute fire hazard in closed metal containers and remove daily from site.
- E. Remove electrical plates, surface hardware, fittings, and fastenings, prior to application of coating operations. Carefully store, clean, and replace on completion of coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finish.

3.2 GENERAL PREPARATION

- A. Prepare surfaces in accordance with coating manufacturer's instructions, unless more stringent requirements are specified in this Section.
- B. Protect following surfaces from abrasive blasting by masking, or other means:
 - 1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
 - 2. Machined surfaces for sliding contact.
 - 3. Surfaces to be assembled against gaskets.
 - 4. Surfaces of shafting on which sprockets are to fit.
 - 5. Surfaces of shafting on which bearings are to fit.
 - 6. Machined surfaces of bronze trim, including those slide gates.
 - 7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used in assembly of equipment requiring abrasive blasting.
 - 8. Galvanized items, unless scheduled to be coated.
- C. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by entering sand or dust.
- D. Concrete:
 - 1. Allow new concrete to cure for minimum of 28 days before coating.
 - 2. Clean concrete surfaces of dust, mortar, fins, loose concrete particles, form release materials, oil, and grease. Fill voids so that surface is smooth. Etch or brush off-blast clean in accordance with SSPC SP-7 to provide surface profile equal to 40 to 60-grit sandpaper, or as recommended by coating manufacturer. All concrete surfaces shall be vacuumed clean prior to coating application.
- E. Ferrous metal surfaces:
 - 1. Remove grease and oil in accordance with SSPC SP-1.
 - 2. Remove rust, scale, and welding slag and spatter, and prepare surfaces in accordance with appropriate SSPC standard as specified.
 - 3. Abrasive blast surfaces prior to coating.

- a. When abrasive blasted surfaces rust or discolor before coating, abrasive blast surfaces again to remove rust and discoloration.
 - b. When metal surfaces are exposed because of coating damage, abrasive blast surfaces and feather in to a smooth transition before touching up.
 - c. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC SP-10, unless blasting may damage adjacent surfaces, prohibited or specified otherwise. Where not possible to abrasive blast, power tool clean surfaces in accordance with SSPC SP-3.
 - d. Ferrous metal surfaces to be submerged: Unless specified otherwise, abrasive blast in accordance with SSPC SP-5 to clean and provide roughened surface profile of not less than 2 mils and not more than 4 mils in depth when measured with Elcometer 123, or as recommended by the coating manufacturer.
4. All abrasive blast cleaned surfaces shall be blown down with clean dry air and or vacuumed.
- F. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPP 500-03.
- G. Sherardized, aluminum, copper, and bronze surfaces: Prepare in accordance with coating manufacturer's instructions.
- H. Galvanized surface:
- 1. Degrease or solvent clean (SSPC SP-1) to remove oily residue.
 - 2. Power tool or hand tool clean or whip abrasive blast.
 - 3. Test surface for contaminants using copper sulfate solution.
 - 4. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded physically, such as bolts, nuts, or preformed channels.
- I. Shop primed metal:
- 1. Certify that primers applied to metal surfaces in the shop are compatible with coatings to be applied over such primers in the field.
 - 2. Remove shop primer from metal to be submerged by abrasive blasting in accordance with SSPC SP-10, unless greater degree of surface preparation is required by coating manufacturer's representative.
 - 3. Correct abraded, scratched, or otherwise damaged areas of prime coat by sanding or abrasive blasting to bare metal in accordance with SSPC SP-2, SP 3, or SP-6, as directed by the ENGINEER.
 - 4. When entire shop priming fails or has weathered excessively (more than 25 percent of the item), or when recommended by coating manufacturer's representative, abrasive blast shop prime coat to remove entire coat and prepare surface in accordance with SSPC SP-10.
 - 5. When incorrect prime coat is applied, remove incorrect prime coat by abrasive blasting in accordance with SSPC SP-10.
 - 6. When prime coat not authorized by ENGINEER is applied, remove unauthorized prime coat by abrasive blasting in accordance with SSPC SP-10.
 - 7. Shop applied bituminous paint or asphalt varnish: Abrasive blast clean shop applied bituminous paint or asphalt varnish from surfaces scheduled to receive non-bituminous coatings.
- J. Cadmium-plated, zinc-plated, or sherardized fasteners:
- 1. Abrasive blast in same manner as unprotected metal when used in assembly of equipment designated for abrasive blasting.
- K. Abrasive blast components to be attached to surfaces which cannot be abrasive blasted before components are attached.

- L. Grind sharp edges to approximately 1/16-inch radius before abrasive blast cleaning.
- M. Remove and grind smooth all excessive weld material and weld spatter before blast cleaning in accordance with NACE SP0178.
- N. PVC and FRP Surfaces:
 - 1. Prepare surfaces to be coated by light sanding (de-gloss) and wipe-down with clean cloths, or by solvent cleaning in strict accordance with coating manufacturer's instructions.
- O. Cleaning of previously coated surfaces:
 - 1. Utilize cleaning agent to remove soluble salts such as chlorides and sulfates from concrete and metal surfaces:
 - a. Cleaning agent: Biodegradable non-flammable and containing no volatile organic compounds.
 - b. Manufacturer: The following or equal:
Chlor-Rid International, Inc.
 - 2. Cleaning of surfaces utilizing the decontamination cleaning agent may be accomplished in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing as approved by the coating manufacturer's representative and the ENGINEER.
 - 3. Test cleaned surfaces in accordance with the cleaning agent manufacturer's instructions to ensure all soluble salts have been removed. Additional cleaning shall be carried out as necessary.
 - 4. Final surface preparation prior to application of new coating system shall be made in strict accordance with coating manufacturer's printed instructions.

3.3 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

- A. Identify equipment, ducting, piping, and conduit as specified in Section 22 05 53 – MECHANICAL IDENTIFICATION and Section 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS.
- B. Remove grilles, covers, and access panels for mechanical and electrical system from location and coat separately.
- C. Prepare and finish coat-primed equipment with color selected by the ENGINEER.
- D. Prepare and prime and coat insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with prefinished coating.
- E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.
- F. Prepare and coat interior surfaces of air ducts, convector and baseboard heating cabinets that are visible through grilles and louvers with 1 coat of flat black paint, to limit of sight line.
- G. Prepare and coat dampers exposed immediately behind louvers, grilles, convector and baseboard cabinets to match face panels.
- H. Prepare and coat exposed conduit and electrical equipment occurring in finished areas with color and texture to match adjacent surfaces.
- I. Prepare and coat both sides and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

- J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming and numbering, in accordance with Contract Documents.

3.4 GENERAL APPLICATION REQUIREMENTS

- A. Apply coatings in accordance with manufacturer's instructions.
- B. Coat metal unless specified otherwise:
 - 1. Aboveground piping to be coated shall be empty of contents during application of coatings.
- C. Verify metal surface preparation immediately before applying coating in accordance with SSPC SP COM.
- D. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.
- E. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.
- F. Prime shop primed metal surfaces. Spot prime exposed metal of shop primed surfaces before applying primer over entire surface.
- G. Multiple coats:
 - 1. Apply minimum number of specified coats.
 - 2. Apply additional coats when necessary to achieve specified thicknesses.
 - 3. Apply coats to thicknesses specified, especially at edges and corners.
 - 4. When multiple coats of same material are specified, tint prime coat and intermediate coats with suitable pigment to distinguish each coat.
 - 5. Lightly sand and dust surfaces to receive high gloss finishes, unless instructed otherwise by coating manufacturer.
 - 6. Dust coatings between coats.
- H. Coat surfaces without drops, overspray, dry spray, runs, ridges, waves, holidays, laps, or brush marks.
- I. Remove spatter and droppings after completion of coating.
- J. Apply coating by brush, roller, trowel, or spray, unless particular method of application is required by coating manufacturer's instructions or these Specifications.
- K. Plural component application: Drums shall be premixed each day. All gauges shall be working order prior to the start of application. Ratio checks shall be completed prior to each application. A spray sample shall be sprayed on plastic sheeting to ensure set time is complete prior to each application. Hardness testing shall be performed after each application.
- L. Spray application:
 - 1. Stripe coat edges, welds, nuts, bolts, difficult to reach areas by brush before beginning spray application, as necessary, to ensure specified coating thickness along edges.
 - 2. When using spray application, apply coating to thickness not greater than that recommended in coating manufacturer's instructions for spray application.
 - 3. Use airless spray method, unless air spray method is required by coating manufacturer's instruction or these Specifications.
 - 4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

- M. Drying and recoating:
1. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.
 2. For submerged service the CONTRACTOR shall provide a letter to the ENGINEER that the lining system is fully cured and ready to be placed into service .
 3. Limit drying time to that required by these Specifications or coating manufacturer's instructions.
 4. Do not allow excessive drying time or exposure which may impair bond between coats.
 5. Recoat epoxies within time limits recommended by coating manufacturer.
 6. When time limits are exceeded, abrasive blast clean and de-gloss clean prior to applying another coat.
 7. When limitation on time between abrasive blasting and coating cannot be met before attachment of components to surfaces which cannot be abrasive blasted, coat components before attachment.
 8. Ensure primer and intermediate coats of coating are unscarred and completely integral at time of application of each succeeding coat.
 9. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
 10. Leave no holidays.
 11. Sand and feather in to a smooth transition and recoat and recoat scratched, contaminated, or otherwise damaged coating surfaces so damages are invisible to naked eye.
- N. Concrete:
1. Apply first coat (primer) only when surface temperature of concrete is decreasing in order to eliminate effects of off-gassing on coating.

3.5 ALKALI RESISTANT BITUMASTIC

- A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements.
- B. Application:
1. Apply in accordance with general application requirements and as follows:
 - a. Apply at least 2 coats, 8 to 14 mils dry film thickness each.

3.6 WAX COATING

- A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements.
- B. Application:
1. Apply in accordance with general application requirements and as follows:
 - a. Apply at least 1/32-inch thick coat with 2-inch or shorter bristle brush.
 - b. Thoroughly rub coating into metal surface with canvas covered wood block or canvas glove.

3.7 HIGH SOLIDS EPOXY SYSTEM

- A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Abrasive blast ferrous metal surfaces to be submerged at jobsite in accordance with SSPC SP-5 prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-10.

- b. Abrasive blast non-submerged ferrous metal surfaces at jobsite in accordance with SSPC SP-10, prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP 6.
- c. Abrasive blast clean ductile iron surfaces at jobsite in accordance with SSPC SP-7.

B. Application:

- 1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply minimum 2-coat system with minimum total dry film thickness (DFT) of 12 mils.
 - b. Recoat or apply succeeding epoxy coats within time limits recommended by manufacturer. Prepare surfaces for recoating in accordance with manufacturer's instructions.
 - c. Coat metal to be submerged before installation when necessary, to obtain acceptable finish, and to prevent damage to other surfaces.
 - d. Coat entire surface of support brackets, stem guides, pipe clips, fasteners, and other metal devices bolted to concrete.
 - e. Coat surface of items to be exposed and adjacent 1 inch to be concealed when embedded in concrete or masonry.

3.8 HIGH SOLIDS EPOXY AND POLYURETHANE COATING SYSTEM

A. Preparation:

- 1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Prepare concrete surfaces in accordance with general preparation requirements.
 - b. Touch up shop primed steel and miscellaneous iron.
 - c. Abrasive blast ferrous metal surfaces at jobsite prior to coating. Abrasive blast clean rust and discoloration from surfaces.
 - d. Degrease or solvent clean, whip abrasive blast, power tool, or hand tool clean galvanized metal surfaces.
 - e. Lightly sand (de-gloss) fiberglass and poly vinyl chloride (PVC) pipe to be coated and wipe clean with dry cloths, or solvent clean in accordance with coating manufacturer's instructions.
 - f. Abrasive blast clean ductile iron surfaces.

B. Application:

- 1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply 3 coat system consisting of:

Primer: 4 to 5 mils dry film thickness high solids epoxy.

Intermediate coat: 4 to 5 mils dry film thickness high solids epoxy.

Topcoat: 2.5 to 3.5 mils dry film thickness aliphatic or aliphatic-acrylic polyurethane topcoat.

- 2. Recoat or apply succeeding epoxy coats within 30 days or within time limits recommended by manufacturer, whichever is shorter. Prepare surfaces for recoating in accordance with manufacturer's instructions.

3.9 EPOXY NOVOLAC SYSTEM

A. Preparation:

- 1. Prepare surfaces in accordance with general preparation requirements and as follows:
- 2. Prepare concrete to obtain clean, open pore with exposed aggregate in accordance with manufacturer's instructions.
- 3. Prepare ferrous metal surfaces in accordance with SSPC SP-5, with coating manufacturer's recommended anchor pattern.
- 4. Complete application of prime coat within 6 hours of abrasive blast cleaning. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-5.
- 5. When handling steel, wear gloves to prevent hand printing.
- 6. Adjust pH of concrete to within 7 to 11 before applying prime coat.

- B. Application:
 - 1. Apply coatings in accordance with general application requirements and in accordance with manufacturer's instructions.
 - 2. Continue to monitor dew point. Dew point shall remain 5 degrees above ambient temperature for a minimum of 8 hours after application of coating.

3.10 HIGH TEMPERATURE COATING

- A. Preparation:
 - 1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Abrasive blast surface in accordance with SSPC SP-10.
- B. Application:
 - 1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply number of coats in accordance with manufacturer's instructions.

3.11 ASPHALT VARNISH

- A. Preparation:
 - 1. Prepare surfaces in accordance with general preparation requirements.
- B. Application:
 - 1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply minimum 2 coats.
 - b.

3.12 COAL TAR EPOXY SUBSTITUTE

- A. Preparation:
 - 1. Prepare surfaces in accordance with general preparation requirements and in accordance with the coating manufacturer's printed instructions.
- B. Application:
 - 1. Apply 2 coats at 6 mils to 8 mils each, for a minimum total DFT of 12 mils.

3.13 VINYL ESTER

- A. Preparation:
 - 1. Prepare surfaces in accordance with coating manufacturer's recommendations and as directed and approved by coating manufacturer's representative.
- B. Application:
 - 1. Apply prime coat, as required by coating manufacturer, base coat, glass mat, and topcoat to total dry film thickness of 125 mils minimum:
 - a. Final topcoat on floors shall include non-skid surface, applied in accordance with manufacturer's instructions.
 - 2. Perform high voltage holiday detection test in accordance with SP0188-06, over 100 percent of coated surface areas to ensure pinhole free finished coating system.
 - 3. All work shall be accomplished in strict accordance with coating manufacturer's instructions and under direction of coating manufacturer's representative.

3.14 ELASTOMERIC POLYURETHANE (100 PERCENT SOLIDS)

- A. Preparation:

1. Prepare surfaces in strict accordance with coating manufacturer's instructions and as directed and approved by coating manufacturer's representative.
- B. Application:
 1. Apply epoxy primer at DFT of 1 to 2 mils, in strict accordance with manufacturer's instructions.
 2. Apply polyurethane coating at minimum total DFT as follows:
 - a. Steel: 60 mils DFT.
 - b. Ductile iron and ductile iron pipe coating and lining: 30 mils DFT.
 - c. Concrete: 120 mils DFT.
 - d. Or as recommended by the coating manufacturer and accepted by the ENGINEER.
- C. For concrete application, provide saw cutting for coating terminations in strict accordance with manufacturer's instructions:
- D. For application to damaged concrete, refer to Section 03_01_03.
- E. Perform high voltage holiday detection test in accordance with SP0188-06, over 100 percent of coated surface areas to ensure pinhole free finished coating system.

3.15 CONCRETE FLOOR COATINGS

- A. Preparation:
 1. Prepare surfaces in accordance with general application requirements and in strict accordance with coating manufacturer's instructions.
- B. Application:
 1. Apply primer if required by coating manufacturer.
 2. Apply 1 or more coats as recommended by coating manufacturer to receive a minimum total dry film thickness of 25 mils, color as selected by OWNER.
- C. Final topcoat shall include non-skid surface, applied in strict accordance with coating manufacturer's instructions.

3.16 WATERBORNE ACRYLIC EMULSION

- A. Preparation:
 1. Remove all oil, grease, dirt, and other foreign material by Solvent Cleaning in accordance with SSPC SP-1.
 2. Lightly sand all surfaces and wipe thoroughly with clean cotton cloths before applying coating.
- B. Application:
 1. Apply 2 or more coats to obtain a minimum dry film thickness (DFT) of 5.0 mils.

3.17 FIELD QUALITY CONTROL

- A. Each coat will be inspected. Strip and remove defective coats, prepare surfaces and recoat. When approved, apply next coat.
- B. Control and check dry film thicknesses and integrity of coatings.
- C. Measure dry film thickness with calibrated thickness gauge.

- D. Dry film thicknesses on ferrous-based substrates may be checked with Elcometer Type 1 Magnetic Pull-Off Gage or Positector 6000.
- E. Verify coat integrity with low-voltage sponge or high-voltage spark holiday detector, in accordance with SP0188 06. Allow ENGINEER to use detector for additional checking.
- F. Check wet film thickness before coal tar epoxy coating cures on concrete or non-ferrous metal substrates.
- G. Arrange for services of coating manufacturer's field representative to provide periodic field consultation and inspection services to ensure proper surface preparation of facilities and items to be coated, and to ensure proper application and curing:
 1. Notify ENGINEER 24 hours in advance of each visit by coating manufacturer's representative.
 2. Provide ENGINEER with a written report by coating manufacturer's representative within 48 hours following each visit.

3.18 PROTECTIVE COATINGS SYSTEMS

- A. System No. 1: Submerged Metal - General

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast, or Centrifugal Wheel Blast (SP 5)	Primer – High Solids Epoxy (Self Priming)	1 coat, 6 MDFT
	Top Coat – High Solids Epoxy	1 coat, 6 MDFT

- B. System No. 2: Submerged Metal – Potable General:

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast, or Centrifugal Wheel Blast (SP 5)	Primer – High Solids Epoxy (Self Priming)	1 coat, 6 MDFT
	Top Coat – High Solids Epoxy	3 coats, 3 MDFTPC

- C. System No. 3: Exposed Metal - Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast (SP 10)	Primer – Per Manufacturer's Recommendations	1 coat, 2.5 MDFT
	Intermediate Coat – High Solids Epoxy	1 coat, 4 MDFT
	Top Coat – Aliphatic Polyurethane	1 coat, 3 MDFT

- D. System No. 4: Exposed Metal – Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
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Abrasive Blast (SP 10)	Primer – Per Manufacturer's Recommendations	1 coat, 2.5 MDFT
	Top Coat – Aliphatic Polyurethane	1 coat, 3 MDFT

E. System No. 5: Buried Metal - General:

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast or Centrifugal Wheel Blast (SP 10)	Standard Hot Coal-Tar Enamel -OR- Coal-Tar Epoxy -OR- Tape Coat System	AWWA C203 AWWA C210 AWWA C214
	For Acidic Soil, Brackish Water High Bacteria - Hot Coal-Tar, Double Felt	AWWA C203, App. A, Sec. A1.5
	For Highly Abrasive Soil, Brackish Water - Hot Coal-Tar, Fibrous Glass -OR- Tape Coat System	AWWA C203, App. A, Sec. A1.5 AWWA C214 with Double Outer Wrap

F. System No. 6 High Temperature (150° - 350°):

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast (SP 10)	Primer – Per Manufacturer's Recommendations	1 coat, 2 MDFT
	Top Coat – High Temperature Coating 150° - 350°	1 coat, 2 MDFT

G. System No. 7 High Temperature (400° - 1000°):

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast (SP 10)	Primer – Per Manufacturer's Recommendations	1 coat, 2 MDFT
	Top Coat – High Temperature Coating 400° - 1000°	1 coat, 2 MDFT 1 coat, 1.5 MDFT

H. System No. 8 High Temperature (1000° - 1400°):

Surface Prep.	Paint Material	Min. Coats, Cover
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Abrasive Blast (SP 10)	Primer – Per Manufacturer’s Recommendations	1 coat, 2 MDFT
	Top Coat – High Temperature Coating up to 1400°	1 coat, 1.5 MDFT

I. System No. 10 Galvanized Metal Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1), followed by Hand Tool (SP 2), or Power Tool (SP 3),	Wash Primer or Coating Manufacturer’s Recommendation.	1 coat, 0.4 MDFT
		Remaining coats as required by exposure

J. System No. 11 Galvanized Metal Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1), followed by Hand Tool (SP 2), Power Tool (SP 3), or Brush-off Blast (SP 7)	Primer – Organic Zinc Rich	1 coat, 3 MDFT Additional coats as required by exposure.

K. System No. 12 Skid-Resistant Aluminum and FRP:

Surface Prep.	Paint Material	Min. Coats, Cover
Brush-off Blast (SP 7) or Plastic Surface Preparation	High Solids Epoxy (aggregated)	1 coat, 16 MDFT

L. System No. 13 Sliding Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1), followed by Hand Tool (SP 2), Power Tool (SP 3), or Brush-off Blast (SP 7)	Wax Coating	1 coat, 31 MDFT

M. System No. 14 Exposed PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
Plastic Surface Preparation	Primer – Per Manufacturer’s Recommendations	1 coat, 2 MDFT

	Waterborne Acrylic Emulsion	1 coat, 3 MDFT
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N. System No. 15 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 1	Alkali Resistant Bitumastic or Coal-Tar Epoxy Substitute	1 coat, 18 MDFT

O. System No. 16 Existing Concrete/CMU Repair:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 13	Filler – Per Manufacturer's Recommendations	1 coat, 10 MDFT
	Primer – Per Manufacturer's Recommendations	1 coat, 5 MDFT
	Top Coat – High Solids Epoxy	1 coat, 4 MDFT

P. System No. 17 New Concrete/CMU Exterior (as required by application schedule):

Surface Prep.	Paint Material	Min. Coats, Cover
SP 13	Filler – Per Manufacturer's Recommendations	1 coat, 10 MDFT
	Intermediate Coat – High Solids Epoxy	1 coat, 4 MDFT
	Top Coat – Aliphatic Polyurethane	1 coat, 3 MDFT

Q. System No. 18 Concrete/CMU – Interior or Immersion Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 13	Filler – Per Manufacturer's Recommendations	1 coat, 10 MDFT
	Intermediate Coat – High Solids Epoxy	1 coat, 6 MDFT
	Top Coat – Aliphatic Polyurethane	1 coat, 6 MDFT

R. System No. 19 Concrete/CMU – Immersion Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 13	Per Manufacturer's Recommendations	As required by conditions

	Epoxy Novolac	2 coat, 40 MDFT Minimum or as called for on the Project Drawings.
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3.19 SCHEDULE OF ITEMS NOT REQUIRING COATING

1. General: Unless specified otherwise, the following items do not require coating:
2. Items that have received final coat at factory and not listed to receive coating in field.
3. Aluminum, brass, bronze, copper, plastic (except PVC pipe), rubber, stainless steel, chrome, Everdur, or lead.
4. Buried or encased piping or conduit.
5. Exterior concrete.
6. Galvanized steel wall framing, galvanized electrical conduits, galvanized pipe trays, galvanized cable trays, and other galvanized items:
 - a. Areas on galvanized items or parts where galvanizing has been damaged during handling or construction shall be repaired as follows:

Clean damaged areas by SSPC SP-1, SP-2, SP-3, or SP-7 as required.

Apply 2 coats of a Galvanizing Zinc Compound in strict accordance with manufacturer's instructions.

7. Grease fittings.
8. Fiberglass ducting or tanks in concealed locations.
9. Steel to be encased in concrete or masonry.

3.20 SCHEDULE OF SURFACES TO BE COATED IN THE FIELD

- A. In general, apply coatings to steel, iron, galvanized surfaces, and wood surfaces unless specified or otherwise indicated on the Drawings. Coat concrete surfaces and anodized aluminum only when specified or indicated on the Drawings. Color coat all piping as specified in Section 40 23 39.
- B. Following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Verify questionable surfaces.
- C. Metal:
 1. System 1 – Submerged Metal – General
 - a. Not Used
 2. System 2 – Submerged Metal – Potable
 - a. Not Used.
 3. System 3 - Exposed Metal – Highly Corrosive
 - a. Not Used
 4. System 4 – Exposed Metal – Mildly Corrosive
 - a. Pipe, valves and fittings that are exposed, including valves and pipe in the valve vault
 5. System 5 – Buried Metal – General
 - a. Buried, below-grade portions of steel items, except buried stainless steel or ductile iron.
 6. Buried, below-grade portions of steel items, except buried stainless steel or ductile iron.
 - a. Not Used
 7. System 6 - High Temperature (150° - 350°)
 - a. Not Used
 8. System 7 - High Temperature (400° - 1000°)
 - a. Not Used
 - b. System 8 - High Temperature (1000° - 1400°)
 - c. Not Used

- d. System 10 – Galvanized Metal Conditioning
- e. Not Used
- f. System 11 – Galvanized Metal Conditioning
- g. Not Used
- 9. System 12 - Skid-Resistant Aluminum and FRP
 - a. Not Used
- 10. System 13 - Sliding Metal
 - a. Not Used
- 11. System 15 - Aluminum and Dissimilar Metal Insulation
 - a. Aluminum surfaces embedded or in contact with concrete, masonry, and other metals.
 - b. Stainless steel embedded in concrete.
 - c. Dissimilar metals for electrical insulation.
- D. Other Materials
 - 1. System 14 - Exposed PVC
 - a. All exterior exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV resistant gel coat.
- E. Concrete:
 - 1. System 17 – New Concrete/CMU Exterior
 - a. Not Used.
 - 2. System 18 – Concrete/CMU Interior or Immersion Mildly Corrosive
 - a. Not Used.
 - 3. System 19 – Concrete/CMU Immersion Highly Corrosive
 - a. Not Used.

END OF SECTION

DIVISION 13
SPECIAL CONSTRUCTION

SECTION 13 34 23.14 – ALUMINUM PUMP COVER

PART 1 - GENERAL

1.1 WORK OF THIS SECTION

- A. This section includes the Work necessary to completely furnish and install a manufactured aluminum pump cover. The aluminum pump cover shall include the enclosure and required components contained in this section.

1.2 GENERAL

- A. Like items of equipment provided hereinafter shall be the end products of one manufacturer to achieve standardization of appearance, operation, maintenance, spare parts and manufacturer's services.
- B. Unit Responsibility: The Work requires that the aluminum pump cover, complete with all accessories; be the end product of one responsible system manufacturer or responsible system supplier. Unless otherwise indicated, the Contractor shall obtain each system from the responsible supplier of the equipment, which supplier shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features, and functions without altering or modifying the Contractor's responsibilities under the Contract Documents. The Contractor is responsible to the Owner for providing the equipment systems as specified herein.
- C. General Requirements: See Division 1, GENERAL REQUIREMENTS, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

1.3 SUBMITTALS

- A. Provide submittal for approval as specified in Section 8.3, SUBMITTALS of Uniform General Conditions for State of Texas Construction Contracts the including no less than the following:
 - 1. Shop Drawings:
 - a. Make, model, and weight of each assembly.
 - b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Detailed mechanical, structural and electrical drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and details of anchorage and of connections to other work, and weights of associated equipment.
 - d. Complete installation instructions.
 - e. Complete description of materials used, including physical properties and methods of manufacture for the fiberglass enclosure.
 - f. Statement that fabrication is in accordance with these Specifications.
 - g. Complete bill of materials.
 - 2. Quality Control Submittals:
 - a. Manufacturer's Certificate of Compliance: Commercial products, including painting/coating systems.
 - b. Special shipping, storage and protection, and handling instructions.
 - c. Test results, reports, and certifications.
 - d. Manufacturer's Certificate of Proper Installation.

3. Contract Closeout Submittals: Service records for maintenance performed during construction.

1.4 OPERATION AND MAINTENANCE DATA

- A. O&M Manuals: Content, form, and schedule.

1.5 WARRANTY

- A. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer will promptly repair or replace the defective equipment without additional cost to the Owner.
- B. Provide warranty for a period specified below after final acceptance of the aluminum pump cover by the Owner and Engineer.
 1. 12 months for the aluminum enclosure.
 2. 12 months for heating and ventilation equipment.
 3. 90 days for electrical equipment or components.
- C. Spare parts identified within this specification shall not be used to address warranty repairs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Materials, equipment, and components, specified in this section shall be products of, or provided by:
 1. Safe-T-Cover, Model 1000TD-AL.
 2. Or Approved Equal

2.2 REQUIREMENTS

- A. The aluminum pump cover inside dimension shall be 96 in wide by 96 in deep by 84 in high and fully contain the packaged booster pump station, as specified in Section 43 42 56.31 POTABLE WATER PUMP STATION SYSTEM; when installed on the concrete pad as shown in the drawings.
- B. The roof, walls & panels of the aluminum pump cover shall be constructed of 5052-H32 (.050/18 gauge) marine grade aluminum, mill finish, ASTM B209 outside with insulation 1 1/2" thick in the walls and panels and 3" thick in the roof.
 1. The aluminum, insulation and redwood shall be securely bonded together to form a composite panel.
 2. The aluminum panels shall be provided with a PVC or similar exterior film to prevent damage before installation. The film shall be removed before installation.
 3. The complete assembly, including valve stems, shall be protected by being inside the enclosure.
 4. The roof shall be securely attached to the walls with screws and inside roof connections.
 5. All screws shall attach to redwood members.
 6. The walls of the enclosure shall be securely attached to the concrete base with inside anchoring brackets.
 7. Access panels shall be four (4) in number and each shall be 38 1/4"W x 84"H. Two access panels shall contain drain panels.
 8. Access panels shall be completely removable.

9. Access panels shall be provided with built-in pad lockable folding T-handles.
 10. Clear opening drain panel area shall be 38 1/2"W x 6 1/2"H.
 11. Drain panel shall have a stainless steel hinge and a stainless steel light strength spring as a positive means of closure so that the drain panel will not be activated by wind.
 12. Drain panel shall be designed to remain closed except during water discharge.
- C. Insulation shall be 1.5" (9.0 "R" value) minimum thickness polyisocyanurate foam laminated to a glass fiber reinforced facer (each side). The insulation shall have the following properties:
1. Dimensional Stability-Less than 2% linear change, ASTM D-2126;
 2. Compressive Strength-20PSI, ASTM D-1621;
 3. Water Absorption-Less than 1% by volume, ASTM C-209;
 4. Moisture Vapor Transmission-Less than one (1) perm, ASTM E-96;
 5. Product Density-Nominal 2.0 lbs. per cubic foot, ASTM D-1622;
 6. Flame Spread=25, ASTM E-84;
 7. Service Temperature= -1000F to +2500F maximum.
 8. The insulation shall be of uniform thickness.
- D. Structural members shall be redwood.
- E. Mounting Hardware
1. Mounting hardware shall be furnished and shall be 300 series stainless steel and/or T-6 aluminum.
 2. All threaded fasteners shall be furnished and shall be 400 series stainless steel and/or Hilti type Tap-Fast w/Quickcoat™ and Flo Seal washer or equal.
 3. All masonry fasteners shall be furnished and shall be stud type Hilti Kwik Bolt II™ and/or Hilti type Hit Anchors or equal.
 4. All necessary drill bits shall be furnished.
- F. Components
1. Heating Equipment
 - a. Heaters shall be wall mounted and furnished and designed by the manufacturer of the enclosure to maintain an interior temperature of +40°F with an outside temperature of -30°F.
 - b. There shall be two heaters and each heater shall be 1kW, 120V, 1 phase, 60 hz. King Model U12100-SS, or equal.
 - c. The heater shall be manufactured from 304SS.
 - d. The heater shall be provided with a thermostat adjustable from +40°F to +90°F. The thermostat, all conduit and wiring fittings provided shall be suitable for "water-tight" installation. The heater shall be not operate when the temperature is above the adjusted thermostat setpoint.
 - e. All necessary wiring and accessories shall be provided for a functional heating system.
 2. Ventilation Equipment
 - a. Supply Fan Wall Shutter
 - 1) Wall shutter shall be rear flanged, vertical mounted, gravity supply (intake) wall shutter. Dayton Model 4HX74, 12" x 12" damper.
 - 2) The frame and blades shall be mill finished aluminum with a galvanized reinforcement strip on each blade for added strength and counter balancing efficiency. The blades have a felt seal on the leading edge for quiet closing and better protection from the weather. Ideal for use with belt-driven centrifugal wall ventilators. The blades shall pivot at the bottom and fall with gravity to open. Spring-assist to close.
 - b. Shutter Mount Exhaust Fan
 - 1) 1/20 HP, 1625 RPM totally enclosed air-over motor, 470 CFM @ 1/8" S.P., Standard 120V, 1 phase, 60 Hz pre wired plug and cord assembly. Provide

with OSHA compliant wire guard, three aluminum gravity shutter blades, disconnect, and remote mounted thermostat. Fan/thermostat initially set to run when temperatures meet or exceed 85 degrees, field verify final setting.

2.3 TOOLS AND SPARE PARTS

- A. Tools: The work includes one complete set of special tools recommended by the manufacturer for maintenance and repair of each separate type of equipment; tools shall be stored in tool boxes, and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

PART 3 - EXECUTION

3.1 GENERAL

- A. Coordination items shall include booster pump station influent and effluent piping and concrete pad, space and structural requirements, clearances, utility connections, signals, outputs, and features required by the manufacturer.

3.2 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. For shipment, the manufacturer's requirements shall be followed.
- B. Delivery of Materials: Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.
- C. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.
- D. Protection of Equipment: Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage. Equipment shall be protected from exposure to corrosive fumes and shall be kept thoroughly dry at all times.

3.3 INSTALLATION

- A. Enclosure shall be mounted on a concrete pad as shown in the drawings. Verify that concrete is level and true to plane and of correct dimensions to receive structure. Correct any deficiencies before proceeding.
- B. Install in strict accordance with manufacturer's directions and recommendations.
- C. Enclosure shall be assembled and mounted to concrete pad in such a way that it will remain locked and secured to pad even if outside screws are removed.

END OF SECTION

DIVISION 26
ELECTRICAL

SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the basic requirements for electrical installations and includes requirements common to more than one section of Division 26. It expands and supplements the requirements specified in the General and Supplementary Conditions.
- B. This project consists of construction of the new building structures, associated facilities, and all related electrical systems as defined in the plans and in these specifications.
- C. The work includes the installation, connection and testing of new electrical equipment, including electrical services, power distribution equipment, lighting equipment, underground electrical work, grounding systems, control systems, conduit and wiring, coordination of traffic flow, temporary power systems, special electrical systems and all appurtenances to construct and demonstrate proper operation of the completed electrical systems.
- D. The Contractor shall be responsible for the coordination of power, communication, and controls for the project.
- E. The electrical plans do not give exact locations, etc., and do not show all the offsets, control lines, pilot lines, and other installation details. Each contractor shall carefully lay out the work at the sites to conform to the job conditions, to conform to details of installation supplied by the manufacturers of the equipment to be installed, and thereby to provide complete operating systems.
- F. The electrical plans show diagrammatically the locations of the various electrical outlets and apparatus and the general method of circuiting and controlling. Exact locations of these outlets and apparatus shall be determined by reference to the general plans and to all detail drawings, etc., by measurements at the buildings, and in cooperation with other crafts, and in all cases shall be subject to the approval of the Owner and Engineer. The Engineer reserves the right to make any reasonable change in location of any outlet or apparatus before installation, without additional cost to the Owner.
- G. These specifications and the accompanying drawings are intended to cover systems which will not interfere with the structure of the buildings, which will fit into the several available spaces, and which will ensure complete and satisfactory systems. Each bidder shall be responsible for the proper fitting of the material and apparatus into the buildings.
- H. Should the particular equipment which any bidder proposes to install require other space conditions than those indicated on the Drawings, the Bidder shall arrange for such space with the Engineer before submitting the bid. Should changes become necessary on account of failure to comply with this clause, the Contractor shall make such changes at the Contractor's expense.
- I. Where wire sizes, conduit and other items of construction are shown or required for a complete installation, but are not adequately identified as to size or material requirements, the materials furnished shall be in accordance with "Code" requirements as though shown in detail on the Drawings.
- J. All equipment shall be leveled and made plumb. Metal junction boxes, equipment enclosures and metal raceways mounted on water or earth-bearing walls shall be separated from walls not less than 1/4 inch by corrosion-resistant spacers. All electrical conduits and items of equipment shall be run or set parallel to walls, floors and other items of construction.

1.2 STANDARDS

- A. The Contractor shall perform work specified in Division 26 in accordance with standards listed below. Where these specifications are more stringent, the most stringent standard shall take precedence. In case of conflict, obtain a decision from the Engineer.
1. Applicable National Fire Protection Association (NFPA) codes, including but not limited to:
 - a. NFPA 70 – National Electrical Code.
 - b. NFPA 70E – Standard for Electrical Safety in the Workplace.
 - c. NFPA 72 - National Fire Alarm Code.
 - d. NFPA 101 – Life Safety Code.
 - e. NFPA 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
 - f. Internet Website: <http://www.nfpa.org>
 2. Applicable Code of Federal Regulations (CFR) codes, including but not limited to:
 - a. 29 CFR 1910 – Occupational Safety and Health Standards (OSHA).
 - b. 29 CFR 1926 – Safety and Health Regulations for Construction.
 - c. Internet Website: <http://www.gpo.gov/fdsys>
 3. ANSI/IEEE C2 – National Electrical Safety Code.
 4. Applicable Federal, State and Local Fire codes.
 5. Applicable Federal, State and Local Energy Codes.
 6. Applicable Federal, State and Local Building Codes.
 7. Applicable City Electrical Code.
 8. Applicable City Ordinances pertaining to electrical work.
 9. Applicable Federal, State and Local – Environmental, Health and Safety Laws and Regulations.
- B. Contractor shall utilize the most current editions of standards, which are current at time of bid and as recognized by the Authority Having Jurisdiction for the respective standard.

1.3 SUBMITTALS

- A. Submittals shall consist of manufacturing information, schematics, wiring diagrams, ladder logic diagrams, instrument loop diagrams, outline drawings, clearances and related information. Shop Drawings shall be so marked as to indicate the EXACT items offered.
- B. Submittals shall bear Contractor's certification that the item complies in all respects with the item originally specified. It is the Contractor's responsibility to procure the proper sizes, quantities, rearrangements, structural modifications or other modifications in order for the substituted item to comply with the established requirements.
- C. The Contractor shall combine each submittal set into one electronic file (pdf format). Group materials submitted by their Specification numbers, but do not submit the entire electrical within one submittal. Provide electronic bookmarks in the pdf to indicate the included equipment types and a title sheet to separate each section.
- D. The Contractor shall submit complete descriptions, illustrations, specification data, etc., of all materials, fittings, devices, fixtures, special systems, etc., as required by the individual sections of this Division.
- E. Submittal of shop drawings, product data and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Engineer will not be processed.
- F. All submittals shall provide the following information:
1. General Contractor.

2. Sub-Contractor.
3. Distributor and/or Supplier.
4. Sales Agency.
5. Submittals not supplying this information will be rejected.

G. Shop Drawings: In addition to the above, submit shop drawings for major materials where called for and when requested by the Engineer.

1. Lockout/Tagout Program.
2. Switchboard, motor control centers, panelboards, surge arresters, and safety switches.
3. Motor starters and contactors including custom wiring diagrams for all motors.
4. Lighting fixtures and lamps including light pole foundation requirements.
5. Wire, cable and conduit.
6. Dry type transformers including weight and dimensions.
7. Wiring devices and plates.
8. Dimensioned layout of electrical room drawn to scale, with equipment location shown therein. Clearances shall be in accordance with NEC and local codes.
9. Dimensioned layout of all below grade conduit installations.
10. Grounding system and layout.
11. Lightning protection system layout.
12. Traffic control system layout and schematics.
13. Seismic protection materials and methods for all electrical equipment.
14. Mounting brackets, supports and assembly for walkway mounted equipment including instruments, lighting and control panels

1.4 QUALITY ASSURANCE

- A. Any electrical equipment provided under this Division shall be turned over to the Owner in operating condition. Instruction on further operation and maintenance shall be included in the operating and maintenance instructions.

1.5 PRODUCT LISTING

- A. Prepare listing of major electrical equipment and materials for the project.
- B. Provide all information requested.
- C. Submit this listing as a part of the submittal requirements.
- D. When two or more items of same material or equipment are required they shall be of the same manufacturer when available. Product manufacturer uniformity does not apply to raw materials, bulk materials, wire, conduit, fittings, sheet metal, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment kits, and similar items used in Work, except as otherwise indicated.
- E. Provide products that are compatible within systems and other connected items.

1.6 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.7 WORK SUPERVISION

- A. The Contractor shall designate in writing the qualified electrical supervisor who shall provide supervision to all electrical work on this project. The minimum qualifications for the electrical supervisor shall be a master electrician as defined by the statutes of the State of the work being performed. The supervisor or his appointed alternate possessing at least a master electrician license shall be on site whenever electrical work is being performed. The qualifications of the electrical supervisor shall be subject to approval of the Owner and the Engineer.
- B. All master and journeyman electricians shall be licensed in accordance with the statutes of the State of the work being performed. No unlicensed electrical workers shall perform work on this project. Apprentice electricians in a ratio of not more than one apprentice per journeyman electrician will be allowed if the apprentices are licensed and actively participating in an apprenticeship program recognized and approved by the statutes of the State of the work being performed.

1.8 PRIMARY UTILITY SERVICE

- A. The Contractor shall install all primary trenching, conduits, and backfilling for the primary service in accordance with utility requirements and utility specifications in conjunction with these plans and specifications.
- B. The Contractor shall be responsible for coordinating all electrical work with the servicing utility prior to construction and providing all equipment, connectors, metering boxes and accessories to make all final connections.

1.9 SECONDARY SERVICE

- A. New electrical work shall be as noted in the drawings. If required, services shall be 120/240 volt, single-phase, three-wire grounded as indicated. All secondary services are to be furnished and installed by the contractor.
- B. The Contractor shall be responsible for coordinating all electrical work with the servicing utility prior to construction and providing all equipment, connectors, and accessories to make all final secondary connections.
- C. The Contractor shall provide temporary service conductors and raceway system as may be required. The Contractor shall then provide and connect permanent service conductors and raceway system after the permanent installation. The Contractor shall coordinate temporary service, installation, metering and all other items as required with the servicing utility. The Contractor shall be responsible for paying all temporary electric monthly metering charges.

1.10 TELEPHONE WORK

- A. The Contractor shall be responsible for coordinating all telephone work with the servicing utility, Owner and Engineer.

1.11 LOCKOUT / TAGOUT PROGRAM

- A. The Contractor shall provide a complete copy of and electrical energy source Lockout/Tagout Program to the Owner, with copy to the Engineer. The document shall clearly identify the on-site master electricians and their contact information, including office and mobile telephone numbers.
- B. The Lockout/Tagout Program shall comply with Part 1910 - Occupational Safety and Health Standards (OSHA) Subpart S – Electrical, and meet the requirements of 29 CFR 1910.147, The

Control of Hazardous Energy (Lockout/Tagout), including requirements listed in 1910.331 through 1910.335.

- C. Implementation of the Lockout/Tagout Program and all other related safety requirements are the sole responsibility of the Contractor.

1.12 SAFETY PROGRAM

- A. The Contractor shall implement an electrical safety program that complies with NFPA 70E and 29 CFR 1926.
- B. Implementation of the Electrical Safety Program, determining and providing proper Personal Protective Equipment (PPE), training and enforcing personnel to wear the prescribed PPE, conducting work area safety inspections (including correcting deficiencies), and all other related safety requirements are the sole responsibility of the Contractor.

1.13 EQUIPMENT CONNECTIONS

- A. General: Provide connections for all equipment installed or modified by this contract, regardless of who furnished the equipment.
- B. Provide all disconnect switches required by Code whether or not shown on the plans.
- C. Contractor shall connect Owner-furnished equipment when specified.

1.14 GENERAL CONDITIONS

- A. The work under this heading is subject to the General and Supplementary Conditions, special conditions for mechanical and electrical work, and the Contractor or subcontractor will be responsible for and be governed by all requirements thereunder as though specifically repeated herein.

1.15 COORDINATION

- A. The Contractor shall coordinate arrangement, mounting and support of all electrical equipment:
 1. To allow maximum possible headroom unless specific mounting heights are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 3. To allow right of way for piping and conduit installed at a required slope.
 4. So connecting raceways, cables and wireways will be clear of obstructions and of the working and access space of other equipment.
- B. The Contractor shall coordinate electrical equipment to be mounted on vendor supplied walkways with supplier.

1.16 SPECIAL NOTE

- A. The mechanical, structural and process plans and specifications, including the general conditions and all supplements issued thereto, information to bidders, and other pertinent documents issued by the Engineer, are a part of these specifications and the accompanying electrical plans, and shall be complied with in every respect. All the above is included herewith, and shall be examined by all bidders. Failure to comply shall not relieve the Contractor of responsibility or be used as a basis for additional compensation due to omission of mechanical, process and structural details from the electrical drawings.

1.17 CONTINUATION OF SERVICES

- A. The Contractor shall install any temporary lines and connections required to maintain electric services and safely remove and dispose of them when complete. The Contractor shall supply emergency power whenever any existing electrical service is without power. In general, the existing facility shall remain operational during construction.
- B. Planned outages shall be coordinated two weeks in advance with duration and time of start approved by the Owner. Changeover work which may be required after normal hours or weekends shall not constitute the basis for additional cost to the Owner. When an outage begins, the Contractor shall proceed directly to completion of the work without unscheduled interruptions or delays due to lack of manpower, equipment or tools.
- C. The Contractor shall refer to the sequence of construction and shall provide temporary connections as may be required to complete each phase of construction as may be required. The Contractor shall submit proposed electrical service plans for each phase of construction to the Owner and Engineer for consideration.

1.18 LAYOUT

- A. The Contractor shall coordinate and establish all bench marks and control lines. The Contractor shall lay out all work. The lay out shall be reviewed by the Engineer and Owner prior to starting any work.

1.19 RELATED WORK SPECIFIED ELSEWHERE

- A. Mechanical Equipment: The Contractor shall rough-in for and make final electrical connections to all motor, panels, fixtures, and equipment furnished under other sections of the specifications, providing all material and equipment required for such final connections, except hereinbefore described. This includes, but is not limited to, control panels and other miscellaneous equipment.
- B. The Contractor shall refer to other sections of these specifications for all information relating to the requirements of all electrical connections to the equipment and shall furnish and install electrical items required for a complete installation, ready for operation.
- C. Roughing-in shall be accomplished from approved shop drawings.
- D. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- E. Refer to equipment specifications in other Divisions for rough-in requirements.

1.20 LOCAL CONDITIONS

- A. Inspection of Sites: The bidder shall inspect the site, thoroughly acquaint himself with conditions to be met and work to be accomplished. Failure to comply with this shall not constitute grounds for any additional payments.

1.21 RECORD DOCUMENTS

- A. Refer to the General and Supplementary Conditions for requirements. The following paragraphs supplement the requirements of the General and Supplementary Conditions:
 - 1. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned for column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit

breaker size and arrangements; support and hanger details; Change Orders; concealed control system devices.

2. The Contractor shall locate all underground and concealed work, identifying all equipment, conduit, circuit numbers, motors, feeders, breakers, switches, and starters. The Contractor will certify accuracy by endorsement. Record drawings shall be correct in every detail, such that the Owner can properly operate, maintain, and repair exposed and concealed work.
3. The Contractor shall store the Record drawings on the site. Drawings shall not be rolled. Make corrections, additions, etc., with pencil, with date and authorization of change.
4. Mark specifications to indicate approved substitutions; Change Orders; actual equipment and materials used.

1.22 OPERATION AND MAINTENANCE DATA

- A. Refer to Section 01 33 00 SUBMITTAL PROCEDURES and Section 01 78 23 OPERATION AND MAINTENANCE DATA for procedures and requirements for preparation and submittal of maintenance manuals.
- B. In addition to the information required by Sections 01 33 00 and 01 78 23, include the following information:
 1. Installation manual: Description of function, installation and calibration manuals, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
 2. Operations manual: Manufacturer's printed operating instructions and procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; summer and winter operating instructions; and all programming and equipment settings.
 3. Maintenance manual: Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 4. Service manual: Servicing instructions and lubrication charts and schedules, including the names and telephone numbers of personnel to contact for both routine periodic and warranty service for equipment and materials provided under this Division.
 5. Final approved equipment shop drawings, clearly labeled.
 6. Final test reports, clearly labeled, including motor certification tests.
 7. Final certified calibration sheets for all equipment and instruments.
- C. After approval of the O&M Manuals, the Contractor shall provide three (3) complete electronic copies of all documentation in Adobe PDF file format using a storage media device of the Owner and Engineer's choosing along with 6 hard copies.

1.23 GUARANTEE

- A. The Contractor shall guarantee the work and materials for a period of one (1) year from the date of completion. If there are failures due to faulty material or workmanship, the Contractor shall correct the failure at no cost to the Owner.
- B. Refer to the General and Supplementary Conditions for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.
 1. Compile and assemble the warranties specified in Division 26, into a separate set of vinyl covered, three ring binders, tabulated and indexed for easy reference.
- C. Provide complete warranty information for each item to include product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

- D. Upon completion of the installation, the Contractor shall adjust the systems to the satisfaction of the Engineer.
- E. This guarantee shall include the capacity and integrated performance of the component parts of the various systems in accordance with the intent of the specifications. The Contractor shall conduct complete tests required by the Engineer to demonstrate the ability of the various systems.

1.24 CLEANING

- A. Clean all light fixtures, lamps and lenses prior to final acceptance. Replace all inoperative lamps.
- B. The electrical system shall be thoroughly cleaned inside and outside, of all enclosures to remove all debris, dust, concrete splatter, plaster paint and lint.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. All materials and equipment used in carrying out these specifications shall be new and have UL listing, or listing by other recognized testing laboratory when such listings are available. Specifications and drawings indicate name, type, or catalog numbers of materials and equipment to be used as standards.

2.2 HEAT TRACING

- A. Heat trace and insulate all exposed piping, water lines, and valves less than 8" diameter and all equipment where water may collect. Where exact sizes, panels, boxes, conduit, circuitry and other items of construction are shown or required for a complete installation, but are not adequately identified as to size or material requirements, the materials furnished shall be as needed to provide freeze protection requirements as though shown in detail on the Drawings. The Contractor shall be responsible for supplying all items as required for complete heat tracing systems regardless of the level of detail shown on the Drawings.
- B. Contractor shall meet all National Electrical code requirements for heat tracing and particularly to Resistance Heating Elements Article 427-21, 22 and 23.

PART 3 - EXECUTION

3.1 SALVAGE

- A. All salvage and equipment removed by the work shall remain the property of the Owner unless directed otherwise by the Owner. Material removed from the project shall be stored on the project site where and as directed. Debris shall be removed from the job site and disposed of by the Contractor.

3.2 DEMOLITION AND DISPOSAL

- A. All conduit, wire, and other electrical appurtenances associated with equipment removed in this project, and no longer in use, shall be removed and stored or disposed of as directed by the Owner. The Contractor shall patch and apply finish to walls, floors, and other structures from which such items are removed to match surrounding colors, textures, or other visual characteristics.

3.3 DELIVERY, STORAGE, AND HANDLING

- A. Deliver equipment to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- C. Equipment and materials shall be stored in accordance with the manufacturer's recommendations and instructions.
- D. All equipment, including but not limited to equipment containing coils and/or electronics, shall be stored in a clean, dry, ventilated and heated building. The storage area shall be free from condensation or other injurious environmental conditions. Freedom from condensation shall be essential and shall be accomplished by the use of auxiliary heaters as required to raise the temperature to 5-degree C above the ambient temperature. The equipment shall be protected from excessive dust.
- E. In addition, certain electronic equipment that requires cooling based upon its specific storage temperature range shall be stored in an air-conditioned building.
- F. All motors shall be stored in a clean, dry, ventilated and heated building. The storage area shall be free from condensation or other injurious environmental conditions. Freedom from condensation shall be essential and shall be accomplished by the use of auxiliary heaters as required to raise the temperature to 5 degree C above the ambient temperature. The motors shall be protected from excessive dust.
- G. Cables and wiring shall be kept in a dry location out of the sun.
- H. Outdoor storage, even when protected by a tarpaulin, is unacceptable.
- I. Equipment may be rejected if the storage criteria are not followed.

3.4 INSTALLATION

- A. Coordinate electrical equipment and materials installation with other building components.
- B. Verify all dimensions by field measurements.
- C. Arrange for chases, slots, and openings in other building components to allow for electrical installations.
- D. The Contractor shall keep ends of conduits, including those extending through roofs, equipment and fixtures covered or closed with caps or plugs to prevent foreign material from entering during construction.
- E. Coordinate the installation of required supporting devices and sleeves to be set in concrete and other structural components as they are constructed.
- F. Sequence, coordinate, and integrate installations of electrical materials and equipment for maintaining the required operation of the facility. Give particular attention to large equipment requiring positioning prior to closing-in the building.

- G. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials.
- H. Where mounting heights are not detailed or dimensioned, install electrical services and overhead equipment to provide the maximum headroom possible.
- I. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- J. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.
- K. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
- L. Coordinate installation of electrical equipment on vendor supplied walkways with supplier.

3.5 MATERIALS AND WORKMANSHIP

- A. All materials shall be new, and shall be of the latest standard design of a manufacturer regularly engaged in the manufacture of that type of equipment. Materials shall be in good condition and shall be free from dents, scratches or other damage incurred in shipment or installation.
- B. All equipment shall comply with the National Electrical Code, Underwriters Laboratories or other appropriate agency.
- C. Installation shall be made in a neat and workmanlike manner, and all materials shall be installed in accordance with the recommendations of the various manufacturers. The installation shall be subject to the approval of the Owner and Engineer.
- D. Incidental materials required to complete the installation as intended by these Specifications shall be of the type and quality in keeping with specified equipment.

3.6 COORDINATION

- A. Carefully examine specification and drawings to be thoroughly familiar with items which require electrical connections and coordination. (Electrical drawings are diagrammatic and shall not be scaled for exact sizes.)
- B. Notify other tradesmen of any deviations or special conditions necessary for the installation of work. Interference between work of various contractors shall be resolved prior to installation. Work installed not in compliance with specifications and drawings and without properly checking and coordinating as specified above shall, if necessary, be removed and properly reinstalled without additional cost to the Owner. Engineer to be mediating authority in all disputes arising on project.
- C. Equipment shall be installed in accordance with manufacturer's recommendation. Where conflicts occur between contract documents and these recommendations, a ruling shall be requested of the Engineer for decision before proceeding with such work.

3.7 CUTTING AND PATCHING

- A. Repair or replace routine damage caused by cutting in performance of work under this Division.

- B. Correct unnecessary damage caused due to installation of electrical work, brought about through carelessness or lack of coordination.
- C. Holes cut through floor slabs to be sleeved or core drilled with drill designed for this purpose. All openings, sleeves, and holes in slabs to be properly sealed, fire proofed and water proofed.
- D. Repairs to be performed with materials which match existing materials and to be installed in accordance with appropriate sections of these specifications.
- E. All cutting and patching work shall be coordinated in advance with the Engineer and Owner prior to any work.

3.8 TRENCHING, EXCAVATION, BACKFILLING, AND REPAIRS

- A. Provide trenching, excavation, and backfilling necessary for performance of work under this Division.

3.9 FOUNDATIONS AND PADS

- A. Foundations and pads required for equipment shall be provided as indicated. Proper size and location of foundations, pads and anchor bolts shall be determined under this Division.
- B. Provide anchors and bases for electrical equipment to withstand lateral forces and accommodate displacements.

3.10 NOISE AND VIBRATION CONTROL

- A. The electrical system as installed shall be free of objectionable noise or vibration. The Contractor shall isolate motors, starters, transformers, equipment, ballasts, etc., as directed or required as to ensure acceptable noise level free from objectionable vibration in all systems.

3.11 TESTS

- A. On completion of work, installation shall be completely operational and entirely free from ground, short circuits, and open circuits. Perform a thorough operational test in presence of the Owner and Engineer. Furnish all labor, materials and instruments for above tests.
- B. Furnish the Engineer, as part of closing file, a copy of such tests including identification of each circuit and readings recorded. Test information to be furnished to the Engineer includes ampere readings of all panels and major circuit breakers, isolation resistance reading of motors and transformers.
- C. Prior to final observation and acceptance test, all electrical systems and equipment shall be in satisfactory operating condition. Including, but not limited to the following:
 1. Electrical power and distribution system.
 2. Lighting systems.
 3. Transformers.
 4. Electric motors for all equipment.
 5. Telecommunication system.
 6. Emergency power system.
 7. Special electrical control systems.
- D. After installation of the electrical system and before operating equipment, functional checking shall be conducted in accordance with the manufacturer's recommendations, with the contract drawings and as follows:

1. Functional checking shall include inspection, testing and repair, replacement or adjustments as necessary to ensure compliance with the requirements of the specifications. Tests and inspections shall be recorded on appropriate yellow lined contract and shop drawings, standard test forms and checklists to indicate that wiring and controls are in place in accordance with requirements and to form the basis of record drawings.
2. The functional test procedures shall be signed and dated by the Contractor and presented to the Owner's construction observation personnel prior to operating any equipment.
 - a. Visual Inspection – The electrical system shall be examined as outlined below:
 - 1). Parts of components missing
 - 2). Improper assembly
 - 3). Parts or components not functioning properly
 - 4). Finish not as specified
 - 5). Materials not as specified
 - 6). Connections not tight
 - 7). Mounting and supports loose or unsatisfactory
 - 8). Nameplates missing or inaccurate
 - b. Grounding System Tests
 - 1). Measure the resistance of the counterpoise grounding system by the rate-of-fall of potential method. Record all measurements on an approved standard test form made specifically for the purpose. The resistance of the grounding system to ground shall not exceed NFPA 70 requirements.
 - c. Continuity Tests
 - 1). Each wire and each wire in each cable rated 300 volts and below shall be tested for continuity. Record wire number and pass or fail on checklist for each wire.
 - d. Dielectric Tests
 - 1). Each power conductor rated 600 volts and above shall be tested (meggered) for dielectric strength to ground.
 - 2). Prior to testing, all components that could be damaged should be disconnected. After testing, the circuit shall still register a resistance value of not less than 1 megohm at 600 volts, dc. This test shall apply between all insulated circuits and external metal parts. Record equipment name, phase or wire number and all observed values for each wire.
 - 3). Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning of all circuits. Record equipment or circuit number and pass or fail on function test checklist for each circuit.
 - 4). The Contractor shall develop non-conforming material reports for each failure. Repair and report failures all failures to Owner and Engineer.
 - 5). The Contractor shall replace defective parts, correct malfunctioning units, make all repairs and retest to demonstrate compliance. The Contractor shall document all actions taken on appropriate non-conforming material report.

3.12 INSPECTION FEES AND PERMITS

- A. Obtain and pay for all necessary permits and inspection fees required for electrical installation.

3.13 IDENTIFICATION OF EQUIPMENT

- A. Properly identify all electrical equipment, including but not limited to the following:
 1. Switchgear, switchboards, motor control centers, and control panels.
 2. Main distribution panel and individual devices within it.
 3. Panelboards and individual devices within it.
 4. Safety switches and disconnects.
 5. Contactors and lighting control center, including all branch circuits.
 6. Individually mounted circuit breakers.
 7. Relays.

8. Transformers.
9. Generators and automatic transfer switches.
10. Any other type of enclosure that includes electrical equipment.

3.14 TEMPORARY LIGHTS AND POWER

- A. Provide a temporary electrical lighting and power distribution system of adequate size to properly serve the following requirements, including adequate feeder sizes to prevent excessive voltage drop. Temporary work to be installed in a neat and safe manner in accordance with the National Electrical Code, Article 590, and as required by OSHA or applicable local safety codes.
- B. Provide one pigtail socket with 150-watt lamp for every 1,000 square feet of floor area, evenly distributed throughout the building and with minimum of one pigtail socket per room.
- C. Provide a minimum of one duplex power outlet for every 1,500 square feet of floor area, evenly distributed throughout the building. Power outlets shall be 20 amp, single phase located as directed by the General Contractor.
- D. Coordinate prior to installation to determine if any lighting or power outlets over the minimum quantity noted above are required.
- E. Provide service and panelboards required for above lighting and power outlets.
- F. The Contractor will pay for power consumption.
- G. Coordinate prior to installation to determine whether single phase or three-phase temporary service is desired.

END OF SECTION

SECTION 26 05 14 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles with integral GFCI and associated device plates.
 - 2. Snap switches and wall-box dimmers.

1.2 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.

1.3 SUBMITTALS

- A. Product Data: for each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.
- C. Samples: One for each type of device and wall plate specified in each color specified.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as type are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers:
 - 1. Cooper wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
5. Or Engineer approved equal.

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20A: Comply with NEMA WD1, NEMA WD 6 configuration 5-20R, and UL 498.
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to the following:
 - a. Cooper; 5351 (single), 5352 (duplex).
 - b. Hubbell; HBL5351 (single), CR5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5381 (single), 5352 (duplex).

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD1, NEMA WD6, UL498 and UL 943, Class A and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20A:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper; GF20.
 - b. Pass & Seymour; 2084.

2.4 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
 - b. Hubbell; CSI221 (single pole), CSI222 (two pole), CSI223 (three way), CSI224 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 12224-2 (four way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole); 20AC3 (three way), 20AC4 (four way).
- C. Pilot Light Switches, 20A:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to the following:
 - a. Cooper; 2221PL for 120 V and 277V.
 - b. Hubbell; HPL1221PL for 120 V and 277V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277V.
 - d. Pass & Seymour; PS20AC1-PLR for 120 V.
 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "OFF."

2.5 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
 1. Plate-Securing Screws: Stainless steel or unbreakable nylon in damp areas.

2. Material: 0.035-inch-(1mm-) thick, satin-finished stainless steel.
3. Provide in-use covers for all exterior installations and interior damp locations.

2.6 FINISHES

- A. Color:
1. Wiring Devices: As selected by Owner, unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint and other material that may contaminate the raceway system, conductors and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting is complete.
- C. Conductors:
1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 4. Existing conductors:
 - a. Cut back and pigtail or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 3. Do not remove surface protection such as plastic film and smudge covers until the last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line voltage: Acceptable range is 105 to 132V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

- C. Test straight blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115g).

END OF SECTION

SECTION 26 05 15 - ELECTRIC MOTORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This section describes materials, installation and testing of induction motors and applies to motors which are generally provided as part of equipment specified in other sections. The Contractor shall provide motors, accessories and appurtenances complete and operable in accordance with the individual driven equipment specifications.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Complete motor data shall be submitted, including:
 1. Machine name and specification number of driven machine.
 2. Motor manufacturer.
 3. Motor type or model and dimensional drawing, including weight.
 4. Horsepower nominal.
 5. Guaranteed minimum full load efficiency. Also, nominal efficiencies at 1/2 and 3/4 load.
 6. Full load speed.
 7. Full load current at rated horsepower for application voltage.
 8. Service factor, minimum 1.15.
 9. Voltage, phase and frequency rating.
 10. Winding insulation class.
 11. Temperature rise class.
 12. Frame size.
 13. Enclosure.
 14. NEMA design.
 15. Thermal protection or over temperature protection.
 16. Wiring diagram for devices such as temperature switches, space heaters and motor leak detection as applicable.
 17. Bearing data, including recommendation of lubricants.
 18. Inverter duty motor for all motors connected to variable frequency drive controllers. Include minimum speed at which motors may be operated.
 19. Power factor at 1/2, 3/4 and full load.
 20. Complete nameplate data, rating and characteristics.
 21. Mounting arrangement, size and location of conduit entries, including lugs.
 22. Factory test results for each motor.

1.3 QUALITY ASSURANCE

- A. Provide routine (short commercial) test data complying with NEMA MG 1-12.51 and MG 1-23.46.
- B. Test thermally protected motors in accordance with NEMA MG 1 winding temperature and trip current tests.
- C. Comply with NEMA MG 1.
- D. Motors for applications in hazardous locations shall bear the UL label listing its use in accordance with the NEC.

1.4 COORDINATION

- A. Furnish reviewed shop drawings from motor controller manufacturer for coordination and sizing of the controller.
- B. Coordinate supplied motor connection box with conduits sizes indicated in the drawings.
- C. Coordinate motor leads and lugs with wire sizes indicated in the drawings.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Unless otherwise specified or specifically required by the manufacturer of the equipment to be driven, all motors shall be single speed, squirrel cage, a-c induction type motors. Electric motors shall be NEMA Design B constant speed squirrel cage induction motors having normal starting torque with low starting current except for motors controlled by variable speed operation and other special motors. In no case shall starting torque or breakdown torque be less than the value specified in ANSI/NEMA MG 1. In all cases, motors shall be suitable for the indicated starting method.
- B. Stator winding shall be copper.
- C. The maximum motor loading of each motor shall not exceed its nameplate horsepower rating (exclusive of service factor) under any operating condition.
- D. Motors shall be sized to start and accelerate the design loading and operate the full range of driven equipment without exceeding any of the specified design requirements. Motors that fail to meet these requirements shall be replaced at no additional cost to the Owner.
- E. All three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated without exceeding Class B temperature rise limits stated in ANSI/NEMA MG1-12, 42. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class. Motors to be operated with variable frequency drives shall be provided with insulation systems to withstand 1600 volt spikes, with dV/dt as defined in NEMA MG 1-31.
- F. All motors shall have a minimum service factor of 1.15.
- G. Motors for use in hazardous locations shall have enclosures suitable for the classification of the location. Such motors shall be UL listed and stamped.
- H. Motors larger than 50 HP located outdoors or in non-conditioned areas shall have 120-volt AC space heaters and temperature sensors.
- I. For motors controlled by variable frequency drives, the critical vibration speed of the motor/load combination shall either not fall within the operating range of the drive or such frequencies shall be blocked with the drive critical speed avoidance circuit. All motors connected to variable frequency drives shall be inverter duty rated.
- J. Unless otherwise specified, motors shall have no-load sound power levels not to exceed the values specified in NEMA MG 1-12.53.3.
- K. Premium Efficiency Motors:

1. Motors with a nameplate rating of 1 horsepower and larger shall be premium efficiency type motors as determined by the testing set forth in ANSI/IEEE 112 – Standard Test Procedure for Polyphase Induction Motors and Generators, Method B. Motors shall be stamped with the efficiency on the nameplate with the caption “NEMA Nominal Efficiency.”
2. Efficiency index, nominal efficiency and minimum efficiency shall be defined in accordance with ANSI/NEMA MG1-12.59 – Efficiency Levels of Energy Efficient Polyphase Squirrel-Cage Induction Motors. All three values are required to be indicated in the submittal.

2.2 MOTOR BEARINGS

- A. All motors greater than 2 horsepower shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.
- B. Motors less than 2 horsepower shall be provided with sealed, permanently lubricated ball bearings.
- C. Horizontal motors over 2 horsepower shall be shielded open-type bearing installed with labyrinth sealed end bells with pipe plugs. Bearings shall be regreasable and have provisions for purging old grease.
- D. Vertical motors over 2 horsepower shall be provided with relubricatable ball, spherical, roller or plate type trust bearings. Lubrication shall be per manufacturer’s recommendation for smooth operation and long life of the bearing. Drains shall be provided to prevent over lubrication.

2.3 MOTOR THERMAL PROTECTION

- A. All single phase motors shall have integral thermal overload protection or shall be current limited.
- B. Winding thermostats shall be provided in accordance with NEMA MG-1. Thermostats shall be snap action, bi-metallic, temperature actuated type switches and shall be provided with a normally closed contact. Thermostats shall be precalibrated by the manufacturer and shall be series connected.

2.4 ACCESSORIES

- A. All vertical motors and horizontal motors 3 horsepower and larger shall have split-type conduit boxes with a gasketed moisture seal between the conduit box and motor frame. Motors less than 3 horsepower shall have the manufacturer’s standard conduit boxes. Motors other than open drip-proof shall be gasketed.
- B. All motors weighing 250 pounds or greater shall have suitable lifting eyes for installation and removal.
- C. Motor grounding lugs shall be provided and shall be suitable for terminating ground wires.
- D. All motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA Standard motor data.
- E. Refer to equipment specifications for special requirements such as space heaters or motor winding thermal protection.

PART 3 - EXECUTION

3.1 STORAGE

- A. Protect motors from exposure to elements for which they are not designed. Install and energize temporary electrical service to motors with electrical heaters.
- B. Store motors in an air-conditioned, ventilated or protected environment similar to or better than the destination environment.

3.2 INSTALLATION

- A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment.
- B. Connections, switches, controls, disconnects and other items shall be provided in accordance with the plans and specifications for each motor.
- C. The Contractor shall coordinate conduit sizes indicated in the drawings with the supplied motor connection box. The Contractor shall be responsible for providing larger connection boxes as may be required.

3.3 FIELD TESTING

- A. Perform insulation resistance tests in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of motor.
- B. Inspect the physical and mechanical conditions of each motor installation including any deviations from the nameplate, drawings, specifications and manufacturer's written guidelines. Verify expected rated voltage, phase and frequency for each motor installation. Confirm the presence of and correct application of lubrications for each motor along with proper securing and torque settings for bolted installations of each motor.
- C. Check for proper phase and ground connections for each motor are connected. For multi-voltage motors, verify that motors are connected properly for the supplied voltage.
- D. Verify that space heaters, where provided, are functional.
- E. Test the motor for proper rotation prior to connection to the driven equipment. Measure and record running current and evaluate the current relative to the load conditions and nameplate full-load amps.
- F. Simulate operating conditions for each motor to demonstrate proper operation of interlocks and control features.
- G. Record operating current in each phase for each motor ½ horsepower and larger. Motors exceeding motor nameplates values shall be repaired or replaced.
- H. For motors 50 horsepower and larger or when a discernible abnormal vibration is detectible, a vibration test shall be completed. Vibration shall not exceed 0.25 in./sec. For horizontal motors, the N-S and E-W vibrations shall be measured at the top and bottom of the front and rear bearing housing. For vertical motors, the N-S and E-W vibrations shall be measured at the upper and lower bearing housing.
- I. All testing shall be witnessed by the Engineer and Owner.

1. Motor and Motor Protection Tests for motors – In addition to other testing start and stop each motor a minimum of 3 times and perform a run test for vibration, heat, and to document motor protection. The Contractor shall document the settings of the motor overcurrent protection, overload relay and similar data on the provided form – MOTOR TEST REPORT.
2. The Contractor shall develop non-conforming material reports for each failure and repair or report failures.
3. The Contractor shall replace defective parts, correct malfunctioning units, make all repairs and retest to demonstrate compliance. The Contractor shall document action taken on appropriate non-conforming material report.

3.4 MOTOR TEST REPORT

- A. The following form is provided for the motor certification specified herein. Master blank forms are available on request.

END OF SECTION

TPWD ENCHANTED ROCK SP W AND WW UPGRADES

MOTOR TEST REPORT

Each electric motor shall be tested for proper operation. Follow manufacturer's testing recommendations and procedures.

1. Name and Horsepower of Motor Tested: _____

2. Overcurrent Protection: _____

3. Overload Protection: _____

4. Visual Inspection Checklist:

- Momentarily Bump Motor Shaft for Proper Rotation
- Motor Frame Bolts
- Shaft Coupling
- Lubricants
- Other Comments:

5. Megger motor from wire in motor control center or control panel and record results:

$\phi A-\phi B$ _____ $\phi B-\phi C$ _____ $\phi C-\phi A$ _____

$\phi A-G$ _____ $\phi B-G$ _____ $\phi C-G$ _____

6. Record full load voltage and current:

V_{ab} _____ V_{an} _____ I_a _____

V_{bc} _____ V_{bn} _____ I_b _____

V_{ca} _____ V_{cn} _____ I_c _____

7. Motor Nameplate FLA: _____

Running Amps: _____

P.F. _____

8. Comments:

Signature Required: _____

Company: _____

Date: _____

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.
- B. Related Sections include the following:
 - 1. Division 26 Section

1.2 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene monomer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency.
- A. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association (NETA) or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.5 COORDINATION

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70. No aluminum on project.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN, XHHW and RHH-RHW-USE.

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper, stranded.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type RHH-RHW-USE single conductors in raceway.

B. Exposed Feeders: Type RHH-RHW-USE, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type RHH-RHW-USE, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type RHH-RHW-USE single conductors in raceway.

E. Feeders in Cable Tray: Type RHH-RHW-USE, single conductors in raceway for larger than 4/0 AWG; Otherwise Type TC tray cable.

F. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

- H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW, single conductors in raceway.
- I. Variable Frequency Drive Branch Circuits: Shielded cable, size adjusted for published ampacity of cable.
- J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- K. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- L. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.
- D. Cable splicing, in general, will not be allowed. Where applicable, all wiring connections to be made using terminal block type connections. Wire nut use will be permitted only where allowed by the Owner and Engineer.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 1. Megger Test of individual conductors to ground after installation.
 2. Visual observation of conductor at accessible locations.
- B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test the following for compliance with requirements.
 - a. All panel feeders.
 - b. All motor feeders.
 - c. All control wires for continuity.
 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Test Reports: Prepare a written report to record the following:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.
 - 1. Underground distribution grounding.
 - 2. Common ground bonding with lightning protection system.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For grounding to include the following in emergency, operation and maintenance manuals.
 - 1. Instructions for periodic testing and inspection of grounding features at test wells ground rings grounding connections for separately derived systems based on ANSI/NETA MTS.
 - a. Test shall be to determine if ground resistance or impedance values remain within specified maximums and instructions shall recommend corrective action if they do not.
 - b. Include recommended testing intervals.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare copper Conductors:
 - 1. Solid Conductors: ASTM B3
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Conductor: No. 4 AWG, stranded conductor or per NFPA 70.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.
 - 1. Bury at least 30 inches below grade.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Bolted connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with ANSI/IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole and Handhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

- D. Pad-Mounted Equipment: Install four ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with utility transformers by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment and components.
- E. Metal Poles Supporting Outdoor Lighting fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact or damage.
- B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
- C. Ground rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit from building's main service equipment, or grounding bus, to main metal water service entrance to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and indicated item, extending around the perimeter of building.
 1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches from building foundation at a depth not less than 30 inches below finished grade.
- J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
 1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at ground test wells. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- B. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
 2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
 5. Substations and Pad-Mounted Equipment: 5 ohms.
 6. Manhole and Handhole Grounds: 10 ohms.
- C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Conduit, ducts and duct accessories for concrete-encased duct banks.
 - 2. Handholes and boxes.

1.2 DEFINITIONS

- A. RNC: Rigid nonmetallic conduit.
- B. SCTE: Society of Cable Telecommunications Engineers.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Accessories for manholes, handholes, boxes.
- B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Reinforcement details/
 - 3. Step details.
 - 4. Grounding details.
 - 5. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - 6. Joint details.
- C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections and elevations, and fabrication and installation details, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Cover design.
 - 3. Grounding details.
 - 4. Dimensioned locations of cable rack inserts and pulling-in lifting irons.
- D. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
- E. Product Certificates: for concrete and steel used in precast concrete handholes, as required by ASTM C858.
- F. Source quality-control test reports.
- G. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI C2.

- B. Comply with NFPA 70.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
- C. Lift and support precast concrete units only at designated lifting or supporting points.

1.6 COORDINATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- C. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions and surface features. Revise locations and elevations from those indicated a required to suit field conditions and to ensure that duct runs drain to manholes and handholes and as approved by Engineer.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Steel conduit: Galvanized. Comply with ANSI C80.1.
- B. PVC-Coated Steel Conduit: Comply with ANSI C80.
- C. RNC: NEMA TC2, type EPPC-40-PVC, UL 651 , with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 PRECAST CONCRETE HANDHOLES AND BOXES

- A. Available Manufacturers: subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
 - 1. Oldcastle Precast Group.
- B. Comply with ASTM C 858 for design and manufacturing processes.
- C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosure are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
 - 1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - 2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive cover-securing bolts.

3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
4. Frame and cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a. Cover Hinges: concealed, with hold-open ratchet assembly.
 - b. Cover Handle: Recessed.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC."
7. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - a. Extension shall provide increased depth of 12 inches.
 - b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
9. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
10. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size shall match fittings to duct or conduit to be terminated.
 - b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
11. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.3 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Description: comply with SCTE 77.
 1. Color: Gray.
 2. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC" or as noted.
 6. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 7. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.
- B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin and reinforced with steel or fiberglass or a combination of the two.
 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
 - a. Amorcast Products Company.
 - b. Quazite
 - c. Carson Industries LLC.

- d. CDR Systems Corporation.
- e. NewBasis.

2.4 UTILITY STRUCTURE ACCESSORIES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
 - 1. Bilco Company (The).
 - 2. Campbell Foundry Company.
 - 3. Carder Concrete Products
 - 4. Christy Concrete Products.
 - 5. East Jordan Iron Works, Inc.
 - 6. Elmhurst-Chicago Stone Co.
 - 7. McKinley Iron Works, Inc.
 - 8. Neenah Foundry Company.
 - 9. NewBasis.
 - 10. Oldcastle Precast Group.
 - 11. Osburn Associates, Inc.
 - 12. Pennsylvania Insert Corporation.
 - 13. Riverton Concrete Products; a division of Cretex companies, Inc.
 - 14. Strongwell Corporation; Lenoir City Division.
 - 15. Underground Devices, Inc.
 - 16. Utility Concrete Products, LLC.
 - 17. Utility Vault Co.
 - 18. Wausau Tile, Inc.

- B. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation and workable at temperatures as low as 35 degrees F. Capable of withstanding temperature of 300 degrees F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

- C. Cover Hooks: Heavy duty, designed for lifts 60 Lb and greater.

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in red blended mix concrete-encased duct bank, unless otherwise indicated. Transition to above ground shall be PVC-coated steel conduit.

3.2 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and boxes for 600 V and Less:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.

3.3 EARTHWORK

- A. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

- B. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top soiling, fertilizing, timing, seeding, sodding, sprigging and mulching.
- C. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.4 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 36 inches, both horizontally and vertically unless otherwise indicated. All below grade elbows and bends to be galvanized.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10- feet from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Grout end bells into structure walls from both sides to provide watertight entrances.
- E. Building Wall or Floor Penetrations: Make a transition from underground duct to concrete encased rigid steel conduit unless otherwise indicated, at least 10 feet outside the building wall without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition.
- F. Sealing: Provide temporary closures at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- G. Pulling cord: Install 100-lbf-test nylon cord in ducts, including spares.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES AND BOXES

- A. Precast Concrete Handhole and Manhole Installation:
 - 1. Comply with ASTM C 891, unless otherwise indicated.
 - 2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
 - 3. Unless otherwise indicated, support units on a level 12" bed of crushed stone or gravel graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- B. Elevations:
 - 1. Install handholes with bottom below the frost line.
 - 2. Handhole covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
 - 3. Where indicated, cast handhole cover frame integrally with handhole structure.

- C. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms as required for installation and support of cables and conductors and as indicated.
- D. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch above finished grade.
- D. Install handholes and boxes with bottom below the frost line.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading form and pour a concrete ring encircling and in contact with, enclosure and with top surface screeded to top of box cover frame.
 1. Concrete: 3000 psi, 28-day strength, with a troweled finish.
 2. Dimensions: 12 inches wide by 12 inches deep.

3.7 GROUNDING

- A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports.
 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION

SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 1. Distribution panelboards.
 2. Lighting and appliance branch-circuit panelboards.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 5. Include evidence of NRTL listing for series rating of installed devices.
 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 7. Include wiring diagrams for power, signal, and control wiring.
 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
- C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

F. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

A. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's written permission.
 - 3. Comply with NFPA 70E.

1.8 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 1 year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Surface-mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 6. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 - 7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- C. Incoming Mains Location: Top and bottom as required by job conditions.

- D. Phase, Neutral, and Ground Buses:
 1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
 1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Main and Neutral Lugs: Compression type.
 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 4. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Square D; a brand of Schneider Electric.
 2. Or equal.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
- D. Mains: Circuit breaker.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Square D; a brand of Schneider Electric.
 2. Or equal.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D; a brand of Schneider Electric.
 - 2. Or equal.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Application Listing: Appropriate for application; Type HACR for breakers serving Heating, Air Conditioning and Refrigeration (HACR) loads.
 - e. Dual rated SWD and HACR breakers are acceptable.

2.5 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.

- B. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete or Miscellaneous Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
 - 2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to panelboards.
 - 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- E. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
- F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- H. Install filler plates in unused spaces.
- I. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- K. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1). Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- F. ADJUSTING
- G. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- H. Set field-adjustable circuit-breaker trip ranges as indicated and recommended by manufacturer.
- I. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes if directed by the Engineer.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.5 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 1. Fusible switches.
 2. Nonfusible switches.
 3. Molded-case circuit breakers (MCCBs).
 4. Molded-case switches.
 5. Enclosures.

1.3 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories and finishes.
 1. Enclosure types and details for all types indicated, including NEMA 250, Type 1.
 2. Current and voltage ratings.
 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 4. Include evidence of Nationally Recognized Testing Laboratory listing for series rating of installed devices.
 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 1. Wiring Diagrams: for power, signal, and control wiring.
- C. Qualification Data: For qualified testing agency.
- D. Field quality-control reports.
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- E. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category from single manufacturer.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.6 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Fuse Pullers: Two for each size and type.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
 - 1. Square D; a brand of Schneider Electric.
 - 2. Or equal.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Lugs: Mechanical type, suitable for number, size and conductor material.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Square D; a brand of Schneider Electric.
 - 2. Or equal.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

2.3 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Square D; a brand of Schneider Electric.
 2. Or equal.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- D. Features and Accessories:
 1. Standard frame sizes, trip ratings and number of poles.

2.4 MOLDED-CASE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include:
 1. Square D; a brand of Schneider Electric.
 2. Or equal.
- B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- C. Features and Accessories:
 1. Standard frame sizes and number of poles.

2.5 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Installation height of disconnect devices shall be in conformance with NFPA 70, Article 240.24.

- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Furnish and install fuses in fusible devices.
- E. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION

SECTION 26 43 13 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
 - 1. Section 262416 "Panelboards" for factory-installed SPDs.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
 - 1. Most manufacturers offer five-year extended warranties on their equipment. Verify available warranties and warranty periods.
 - 2. Warranty Period: **Five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be the nominal system voltage.
- E. Comply with UL 1283.
- F. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 240kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- G. Protection modes and UL 1449 VPR for grounded wye circuits with 240/120 V, Single-phase, 3-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 700 V for 120 V.
 - 2. Line to Ground: 1200 V for 120 V.
 - 3. Line to Line: 1000 V for 240V.
- H. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 700 V.
 - 2. Line to Ground: 700 V.
 - 3. Line to Line: 1000 V.
- I. SCCR: Equal or exceed 100 kA.
- J. Inominal Rating: 20 kA.

2.2 PANEL SUPPRESSORS

- A. SPDs: Comply with UL 1449, Type 2.
 - 1. Include LED indicator lights for power and protection status.
 - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.

- B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- C. Comply with UL 1283.
- D. Protection modes and UL 1449 VPR for grounded wye circuits with 240/120 V, Single-phase, Three-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 700 V for 120 V.
 - 2. Line to Ground: 700 V for 120 V.
 - 3. Neutral to Ground: 700 V for 120 V.
 - 4. Line to Line: 1200 V for 240V
- E. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 700 V.
 - 2. Line to Ground: 700 V.
 - 3. Neutral to Ground: 700 V.
 - 4. Line to Line: 1200 V.
- F. SCCR: Equal or exceed 100 kA.
- G. Inominal Rating: 20 kA.

2.3 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: Type 4X.

2.4 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
- C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- D. Use crimped connectors and splices only. Wire nuts are unacceptable.

- E. Wiring:
 - 1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

SECTION 26 90 00 – GENERAL INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. The work to be included under this section shall consist of furnishing all materials, labor, equipment, tools, supplies, and incidentals necessary for the installation and testing of all instrumentation, control, and SCADA systems.
- B. Related Sections:
 - 1. 26 90 10 - Process & Analytical Instruments
 - 2. 26 90 50 – Remote Telemetry System

1.2 REFERENCES

- A. Definitions: Symbols, Definitions, and Abbreviations: All symbols, definitions, and engineering unit abbreviations utilized shall conform to IEEE 100-84, S50.1, and S51.1, where applicable.
 - 1. SCADA – Supervisory Control and Data Acquisition
 - 2. HMI – Human Machine Interface (Graphical Screens, Text Displays)
 - 3. OIT – Operator Interface Terminal
 - 4. PLC – Programmable Logic Controller
 - 5. I/O – Input/Output
 - 6. RTU – Remote Telemetry Unit
 - 7. MTU – Master Telemetry Unit
 - 8. Operating Program – Operating system, SCADA or other core software
 - 9. Integrated Operating Platform – System of installed, connected, and configured hardware, operating programs, and networking equipment.
 - 10. PLC and HMI Programming – Software configuration of operating programs to implement plant control strategies
 - 11. BPCS – Basic Process Control System -

1.3 SCOPE

- A. The scope of the instrumentation, control, and SCADA system for this project includes:
 - 1. Process Control: Furnishing, installing, and configuring PLC panels and OITs to control the process equipment as detailed on the Drawings and in the Specifications. PLC panels in this project, other than those included as part of vendor supplied equipment, are listed below:
 - a. PLC Panel
 - b. SCADAPACK Panel
- B. All instruments, PLC control panels and remote telemetry systems shall be furnished by the Contractor with the exception of items furnished as part of an equipment package. The Contractor shall be responsible for coordinating installation and commissioning of the required site control system. Coordination shall include equipment suppliers and subcontractors required to implement a complete and functional system as described herein.
 - 1. All software shall be purchased, installed and pre-configured under this contract.
 - 2. References to Contractor in this specification shall include subcontractors engaged by the Contractor for furnishing control system equipment, operating programs, and the integrated operating platform.
 - 3. With the exception of items furnished under this contract as part of an equipment package, PLC and HMI programming shall be by an application programmer selected and compensated by this contract.

4. The Contractor shall execute the Control Panel Readiness, Site Acceptance and Final Acceptance Tests outlined in this document.
5. A schedule for the Control Panel Readiness, Site Acceptance, and Final Acceptance tests shall be submitted as part of the Baseline Schedule, set forth in Section 01 32 00, to the Owner and Engineer for review within 45 days of the NOTICE TO PROCEED.

1.4 SUBMITTALS

- A. Product Data:
 1. Instrument Installation Details.
 2. Instrument Specification Sheets: See Specification 26 90 10 – Process and Analytical Instruments.
 3. Certified Calibration Sheets.
 4. Complete and detailed instruction manuals on each item furnished including but not limited to all devices and instruments. Information to be contained in the instruction manuals shall include but not be limited to drawings, dimensions, manufacturer's recommendations, ratings, performance charts, power requirements, schematics, maintenance requirements and procedures, calibration recommendations and procedures, repair instructions, complete and recommended spare parts lists and related information.
 5. Proposed tagging and attachment materials and methods.
- B. Shop Drawings shall be submitted for approval by the Engineer.
 1. The Contractor shall submit to the Engineer, for approval, Shop Drawings of the equipment to be installed to meet the Specifications. The Drawings shall be supported by notes or written directions as required to fully define the installation. The submission shall be made as soon as feasible after award of the Contract and, in any event, shall be submitted and approval obtained before installation of the equipment.
 2. The information required on the Shop Drawings shall include, but is not necessarily limited to, the following:
 - a. Full and complete specifications covering the equipment proposed to be furnished.
 - b. Detail Drawings showing plan, network connections and elevation dimensions of the equipment proposed to be furnished.
 - c. Guarantees of performance of the equipment proposed to be furnished.
 - d. Nearest location of factory maintenance and service facilities that will be available to service the equipment offered.
 - e. To scale plans, sections and elevations detailing entire installation. Include mounting hardware, brackets, assemblies and other devices as required for a complete installation.
 3. Control panels:
 - a. Panel and sub-panel layout
 - b. Point-to-Point Wiring Diagrams
 - c. Interconnection drawings
 - d. System hardware
- C. Third Party Certification documents shall be submitted for approval by the Engineer:
 1. Credentials of technicians doing the inspection and testing
 2. Written certification as detailed under Third Party Certification in this specification section
- D. Contract Closeout Submittals:
 1. Project Record Documents
 2. Operating and Maintenance Data
 3. Warranty
 4. Final as-built copies of documented PLC and OIT programs furnished by Contractor on electronic media, suitable for future troubleshooting or modifications by others.

5. Final as-built copies of documented PLC and OIT programs for vendor supplied equipment packages, on electronic media, suitable for future troubleshooting or modifications by others.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Storage and Protection: Delivery, storage, and handling shall be in accordance with Manufacturers' recommendation and the requirements of General Conditions and other sections herein.

1.6 PROJECT AND SITE CONDITIONS

- A. Environmental Requirements: Instrumentation and control elements may be installed outdoors exposed to sun, rain and excessive humidity and shall be capable of continuous operation without significant reduction of their operating life under the following ambient conditions:

Temperature	-25 °C to 80 °C
Pressure	650 mm Hg to 800 mm Hg
Relative Humidity	20% to 100% condensing
Vibration Frequency:	10 - 2000 Hz.
Vibration Position	1.5 mm peak-to-peak
Vibration Acceleration	10 G.

- B. Where the ratings of individual components cannot meet the requirements, provide suitable means of physical protection. Suitable physical protection shall consist of an assembly which meets the requirements listed, while limiting the ambient conditions at the non-conforming component to 90% of the component's rating (Example: A component rated for vibration at only 5 G. acceleration would be required to be combined with vibration isolation to limit the acceleration of the component to 4.5 G. when subjected to ambient acceleration of 10 G. from 10 - 2000 Hz.).
- C. Operating Environmental Conditions: All instruments and control devices provided shall be rated for continuous operation in their installed operating environment and shall be capable of continuous operation at the operating conditions without significant reduction of their operating life.
- D. All controlling devices shall be NEMA or IEC rated.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. All meters, instruments, control units, and other components shall be the most recent field proven models marketed by their respective manufacturers at the time of the submittal of the shop drawings unless otherwise specified to match existing equipment.
- B. Analog measurements and control signals shall be electrical and shall vary in direct linear proportion to the variable being measured. All analog signals whether inputs or outputs shall be 4-20mA DC unless otherwise noted. The analog input signals shall maintain loop integrity with the installation of properly sized resistors across the input terminals.
- C. All of the elements, instruments, accessories, and assemblies shall be installed in accordance with the manufacturer's installation instructions, and as detailed on the Drawings. Shielded instrumentation cables shall be used for all analog signals from the instruments to the programmable logic controller panels. Separate conduits shall be used for instrument power, instrument signals, and fiber optic cables.
- D. All instruments installed outdoors shall include a stainless steel enclosure with sunshade.
- E. All digital outputs shall be isolated from the field equipment through an interposing relay. The relays shall be mounted inside the cabinet housing the associated programmable logic controller as shown on Drawings.
- F. The Contractor shall make the necessary power connections and signal connections from the field devices (i.e. instruments, control valves, etc.) to the programmable logic controllers.
- G. The Contractor shall configure and verify proper operation of the Integrated Operating Platform, included but not limited to the following requirements:
 - 1. PLCs, OITs, ethernet switches, surge protection devices, uninterruptible power supplies, and other incidental equipment shall be configured and installed as shown on the Drawings and as specified herein.
 - 2. All networked devices shall be configured for proper communication via the topology and protocol shown on the Drawings or specified herein.
 - 3. Verify that all system devices power up, function and properly communicate prior to commencing any startup or testing procedures as described herein.

3.2 TESTING AND INSTALLATION REQUIREMENTS

- A. Testing and Installation Requirements: The Contractor shall be required to coordinate the following services during construction related to the testing and installation of the instrumentation and control system. The complete system testing shall include all PLCs, computer systems, SCADA software and hardware, network devices, remote telemetry devices, interconnecting cables, and other peripheral devices required for a complete and functional system. The testing of the system shall occur in three stages: a Control Panel Readiness Test, a Site Acceptance Test, and a Final Acceptance Test.
- B. Control Panel Readiness Test
 - 1. The Contractor shall conduct a Control Panel Readiness Test for each control panel at a facility located within fifty miles of the project construction site. The test shall include the Engineer and Contractor. The Owner may also attend this test. The Contractor shall

coordinate with the Engineer and Owner to schedule this test a minimum of thirty (30) days in advance.

2. The Contractor shall assemble all hardware components within the specified enclosures, including the instruments, PLCs, OITs, network components and other required items. This assembly shall be complete and considered suitable for field installation.
3. For the Control Panel Readiness Test, the Contractor shall demonstrate that each control panel is suitable for field installation by powering up each item and testing for proper network connections. In addition, the Contractor shall test each PLC input and output for proper operation from each field connection point within each control panel. The Contractor shall be responsible for all measurement and testing components required to complete the Control Panel Readiness Test.
4. The Contractor shall be responsible for connecting test instruments to each PLC and OIT and verifying proper operation of each input and output. The Contractor shall provide test screens for the OITs and test programming for each PLC. All wire and terminal numbers will be checked for conformance with the submittal drawings during this Readiness Test.
5. Each analog I/O point shall be checked for proper operation from each field connection point in the control enclosure and confirmation of each item shall be properly displayed on each associated OIT as applicable. The Contractor shall be prepared to simulate several inputs and outputs in order to fully confirm the proper operation of each analog I/O.
6. After the Engineer (and Owner if in attendance) are satisfied that the system is fabricated as intended, the Contractor will then be authorized to ship the system to the project site for installation.

C. Third Party Certification: Prior to the Site Acceptance Test, the Contractor shall furnish to the Engineer written certification from a third party that all system components, panels, communications, control wiring, device configurations, instrument calibrations, motor controllers, and variable frequency controllers and associated integration have been installed in conformance with the Contract Documents.

1. Said certification shall include energization and testing for correct hardware integration of all system components, including PLC remote I/O assemblies, and reliable communications between components with correct protocols.
2. Analog input and output channels shall be verified at 0 percent, 25 percent, 50 percent, 75 percent, and 100% of span.
3. Personnel performing the third party certification shall have International Society of Automation (ISA) Certified Control Systems Technicians (CCST) or equivalent credentials as approved by the Engineer or Owner.
4. A written Third Party Certification that all aforementioned systems are installed and operational in conformance with the Contract Documents shall be submitted to the Engineer.

D. Site Acceptance Test

1. Upon the Engineer's written approval of the Third Party Certification, the Site Acceptance Test may be scheduled and executed.
2. Coordination with Engineer and Owner: The Contractor shall coordinate with the Engineer and Owner to schedule this test a minimum of thirty (30) days in advance.
3. The Contractor shall conduct a Site Acceptance Test at the Owner's facility following system installation and prior to startup. The test shall include complete in-service testing of all system components, panels, communications, and OITs to ensure conformance with the Contract Documents. The Engineer and Owner may decide to witness these tests.
4. The Contractor shall ensure that components having adjustable features are set carefully for the specific conditions and applications of this installation and that the components and systems are within the specified limits of accuracy. Defective elements which cannot achieve proper calibration or accuracy, either individually or within the system or subsystem, shall be replaced.

5. Test Conditions: Where feasible, system testing and commissioning shall include the use of air or water to establish service conditions that simulate, to the greatest extent practical, normal final control element operating ranges and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under startup and steady-state operating conditions to verify that proper and stable control is achieved.
6. Failure to Complete Site Acceptance Test: If the Site Acceptance Test is not completed due to installation errors, the Contractor shall repeat the Third Party Certification process and resubmit certification to the Engineer at no additional cost to the Owner. After Engineer approval of the new Third Party Certification submittal, the Site Acceptance Test shall be repeated. The cycle of Third Party Certification and Site Acceptance Testing shall be repeated at no cost to the Owner until all systems work correctly as determined by the Owner and Engineer.

E. Final Acceptance Test:

1. The Contractor shall conduct a 10-day Final Acceptance test of the completed installation. The test shall start after the Engineer has received marked record (as-built) drawings from the Contractor and when directed by the Owner/Engineer. The Contractor's personnel shall be readily available to address issues onsite during the acceptance test.
2. The system shall operate with 100% reliability during the test period. Failure shall be defined as the inability to control or indicate status of specified inputs or outputs or any specified function of the control systems as described herein caused by defective hardware or software furnished in this project. Failure of hardware or software shall require repair or remedy of the defect to the satisfaction of the Engineer within a two hour period. If the problem cannot be repaired in this time, the test shall be aborted and restarted after the problem is corrected and when directed by the Owner/Engineer. Restarting and satisfactory completion of the test shall be conducted at no additional cost to the Owner.
3. The Contractor shall complete the Operations and Maintenance Manuals including all updated documentation of programmable devices to the satisfaction of the Engineer.
4. The Contractor will be allowed two attempts at successfully completing the Final Acceptance Test. After that time, the Contractor will become responsible to reimburse the Owner for liquidated damages. Successful completion of the Final Acceptance Test will be required prior to Substantial Completion.

3.3 TRAINING, STARTUP ASSISTANCE, & WARRANTY

- A. Training: The Contractor shall provide training for the purpose of familiarizing Owner's personnel with the instrumentation and control system. All training shall be as scheduled by the Owner. The training shall be scheduled a minimum of thirty (30) days in advance of when it is to be given. Proposed training materials, including a detailed training agenda itemizing relative emphasis on various topics of each course, shall be submitted to the Owner and Engineer at least fourteen (14) days in advance of when the training is to begin. The course content shall include, but not be limited to, a description of system philosophy, all major hardware components utilized in the system and hardware maintenance practices.

B. Startup Assistance

1. The Contractor shall be responsible for furnishing a qualified technical representative who shall supervise the installation of equipment and/or install equipment, and who shall test, adjust, field calibrate, and fully commission all flow metering equipment, instrumentation equipment, control equipment, and accessories specified herein and required as integral components of the complete systems. The commissioning will be deemed to be complete only after all systems are found to be performing satisfactorily following the final balancing of plant operation. The guarantee period, during which all defective materials shall be replaced and all faulty workmanship will be corrected at no

cost to the Owner, shall begin with the date on which the commissioning is judged to be complete.

C. Service:

1. Manufacturers shall provide as part of the equipment cost sufficient days of service by a factory-trained service engineer specifically trained on the type equipment herein specified to assist the Contractor during installation and start-up. The service time shall be sufficient to place the units in satisfactory service and instruct the Owner's personnel in proper operation and maintenance of the equipment.
2. A minimum of three (3) days service Engineer time shall be provided.

D. Warranty:

1. All equipment and workmanship furnished under this contract shall be guaranteed to be free of defects in materials and workmanship for a period of two (2) years from and after the date of final acceptance of the work by the Owner, and any such defects which appear within the stipulated guaranty period shall be repaired, replaced or made good without charge. This guarantee shall include the capacity and integrated performance of the component's parts.

END OF SECTION

SECTION 26 90 10 – PROCESS AND ANALYTICAL INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. The work to be included under this section of the Specifications shall consist of furnishing all materials, labor, equipment, tools, supplies, and incidentals for installation of all instrumentation equipment. The work shall include every item of construction necessary for a complete and acceptable installation as shown on the Drawings and as specified herein.
- B. Related Sections:
 - 1. 26 90 00 - General Instrumentation and Control

1.2 REFERENCES

- A. ISA S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves
- B. ISA S50.1 - Compatibility of Analog Signals for Electronic Industrial Process Instruments
- C. ISA S51.1 - Process Instrumentation Terminology
- D. ISA S51.1; Sec. 5 - Test Procedures
- E. Definitions: Symbols, Definitions, and Abbreviations: All symbols, definitions, and engineering unit abbreviations utilized shall conform to IEEE 100-84, S50.1, and S51.1, where applicable.
 - 1. SCADA – Supervisory Control and Data Acquisition
 - 2. HMI – Human Machine Interface
 - 3. PLC – Programmable Logic Controller
 - 4. I/O – Input/Output
 - 5. OIT – Operator Interface Terminal
 - 6. RTU – Remote Telemetry Unit
 - 7. MTU – Master Telemetry Unit
 - 8. N.O. – Normally Open
 - 9. N.C. – Normally Closed

1.3 SCOPE

- A. This section of the Specifications covers the instrumentation equipment. The major items of instrumentation equipment to be furnished and installed shall include the following:
 - 1. Pressure Indicating Transmitters
 - 2. Pressure Gauge

1.4 SYSTEM REQUIREMENTS

- A. Design Requirements:
 - 1. Provide analog field instruments with transmitters which condition the signal to output a 4-20 mA signal linear to the measured variable.
 - 2. Similar instruments shall be by the same Manufacturer to the extent practical.
- B. Performance Requirements:
 - 1. Accuracy:
 - a. Accuracy shall be as defined in ISA S51.1 and ISA S51.1, Sec. 5. Provide a complete and operating instrument installation with measurement accuracy

determined by adding the accuracy of the element and the transmitter and any wiring to the field terminal enclosure of 0.75% of calibrated span or better, unless specified otherwise below, at any environmental condition specified.

2. Ranges:
 - a. The expected range of each instrument shall be as directed by the Owner and Engineer. Expected ranges shall correspond to actual field conditions.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- A. Furnish instruments specified in the instrument specification sheets at the end of this section. Instruments for services not listed shall be equal in quality, performance, and environmental and functional characteristics as instruments listed and shall be approved in writing by the Owner.

2.2 INSTRUMENT ACCESSORIES

- A. Instrument and Control Device Tags: Each field mounted field device shall be identified by its unique tag number as it appears on the original P&I diagrams and the Instrument Loop Diagram. The tag number shall be stamped on a 1" x 2" stainless steel tag permanently attached to the instrument by braided stainless steel wire which has been sealed by an approved method such that the wire must be cut or the seal broken to remove the tag. The tag number shall not be stamped on the nameplate of the instrument. This requirement shall be documented on the Instrumentation Specification Sheet.
- B. Sunshades: Furnish stainless steel sunshades for all outdoor instruments not shaded by adjacent or integral equipment.
- C. Process Tubing: Stainless Steel, ASTM A 269, TP316, seamless, annealed, 1/2" x 0.065" W.T. minimum.
- D. Pneumatic Supply Tubing: Stainless Steel, ASTM A 269, TP316, seamless, annealed, 1/2" x 0.065" W.T., 3/8" x 0.049" W.T. and 1/4" x 0.035" W.T. minimum.
- E. Fittings: 316 Stainless Steel ferrule type, SWAGELOCK or equal.
- F. Pipe Stand Type Supports for Instrumentation: Pipe stands shall be stainless steel using welded fabrications with 2" schedule 40 pipe, 2" square tube x 0.188" thick, 3/8 zinc/cadmium plated hardware, 1/2" expansion anchors, 12 gauge mounting channel and 1/4" thick stainless steel plate as a minimums. Supply u-bolts or cable mounts as necessary. Acceptable alternatives include engineered pipe stand systems such as O'Brien Saddlepak.
- G. Enclosures for outdoor locations: Furnish and install NEMA 4X enclosures. All outdoor enclosures with instrumentation accessible in enclosure door shall have a stainless steel sunshade.

2.3 CALIBRATION

- A. Order instruments factory calibrated to the range indicated with calibration sheets indicating certification of traceability to National Institute of Standards and Technology (NIST). Instruments shall be ranged as directed by Engineer.

2.4 FABRICATION

- A. Materials of Construction: Provide 316 Stainless Steel for wetted and other parts unless otherwise specified.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Installation
 1. Install sensing elements at the point of measurement and route sensing line or cable to the transmitter. Install the transmitters 4'-6" above grade or platform in an easily accessible location adjacent to the sensor location. Mount on pipe stanchion or steel support designed for the purpose individually or grouped with other transmitters. Furnish and install surge protector Phoenix Contact PipeTrab 2818122 or equal in each 4-20 mA current loop, adjacent to each respective instrument. Route signal cable in conduit from transmitter to terminal cabinet or control panel for termination to test terminals. Steel supports shall be in accordance with this Section, and all other sections and specification requirements. Process connections for instrumentation shall be in accordance with piping sections and all other specification requirements. Provide block valves at taps for pressure or sampling sensor lines. Provide plugged tees at taps suitable for rodding or blowing out taps. Make pipe taps with weld-o-let type fittings or equal. Install block valves suitable for the service and rated as the pipe at each tap, generally use NPT threaded ball valves. Use materials rated for the service and transition to tubing for sensor runs. Use 1/2" OD 316 SS tubing or as shown on the Drawing details.
- B. Flow Instruments: Mount magnetic flowmeters according to manufacturer's instructions with any reducers necessary. Install grounding rings and ground magnetic flowmeters according to manufacturer's instructions.
- C. Pressure Instruments: Make pressure taps in top of pipe for gas service and side of pipe for liquid or steam service.
- D. Pressure Gauges: Use 1/2" NPT pipe and ball or needle valve for pressure gauge taps. Mount gauges vertically; provide 90° fitting, seal, snubber or siphon tube as required. Where 90° fitting is required, install a tee-fitting with plug.
- E. Differential pressure and level transmitters: Use 1/2" tubing and ball or needle valves for pressure taps. Slope tubing runs 1" per foot to drain the sensing line to the pipe where the transmitter is higher than the tap and to drain the line to the transmitter where the transmitter is lower than the tap. At the transmitter connection provide a valve manifold that can block, bleed, vent, purge and provide calibration ports to the transmitter. For gas service transmitters, route 1/2" tubing straight up from the tap for a minimum of 12" to a high point in the line, then with a minimum slope of 1" per foot to the transmitter connection. Provide an automatic condensate drain at the transmitter.
- F. Temperature instruments: Generally mount thermocouple assemblies in the side of the pipe at a minimum angle of 15° up from horizontal and route thermocouple or RTD cable to the transmitter in conduit. Do not mount thermocouples absolutely horizontal or at angles below horizontal. Provide adequate clearance for removal of head assembly and extraction of sensor.
- G. pH elements: For pH elements mounted in sample lines, mount according to Manufacturer's instructions in an insertion assembly which permits removal of the element while the process line is pressurized. Mount with the element vertical and in a trap to keep electrodes hydrated. Arrange taps and sensor lines to keep flow velocity at sensor below 10 ft. / sec.

1. Mount all instrumentation according to manufacturer's instructions except as specified.
- H. Tubing and Fittings:
1. Install tubing and fittings in a neat, orderly and functional manner; level and plumb except as required, noted on approved drawings, or specified. Make offsets required for fittings or equipment level in the horizontal plane to prevent high or low spots.
- I. Conduit and fittings:
1. Install conduit as required. Provide a cast body tee fitting at the instrument connections at the low point of all conduit runs below the instrument with a drain fitting for condensate. Make connections from instrument to tee with liquid-tight flexible conduit and use sealing compound inside the conduit and shrink-fit tubing over the outside of the connection to prevent entry of water into the instrument. Heat trace and insulate all liquid filled lines and the sensing body of all instruments connected to liquid service in exterior locations.
- J. Calibration: Calibrate each and every instrument connected to the work of this contract in its range, whether furnished under this contract, owner-furnished or existing and fill out a signed and dated five point calibration sheet and install an initialed and dated calibration sticker. Notify the Owner in writing immediately of any instrument which will not calibrate. Instruments that do not calibrate will require the on-site services of a factory authorized representative at no cost to the Owner.

INSTRUMENT SPECIFICATION SHEETS:

INSTRUMENT SPECIFICATION SHEET

PRESSURE GAUGE

Operating Pressure Range	Varies with application	
Pressure Connection	1/2" National Pipe Tapered Thread	
Wetted Material	Brass	
Mounting	See Drawings for location.	
Suppliers	Ashcroft Duragauge Model 1279/1379, Robert Shaw Acragage, or equal	
Instrument Tag	Application	Range
PI01	Discharge Header Pressure	0-75 psi

INSTRUMENT SPECIFICATION SHEET

PRESSURE TRANSMITTER

Output	4-20 mA, proportional to pressure	
Accuracy	±.5% of span	
Operating Temperature	-40 °F to 175 °F	
Process Connection	½" NPT	
Housing Material	Low Copper Aluminum	
Power Supply	24 VDC	
Display	Local LCD Display	
Suppliers	Rosemount 2088 or equal	
Instrument Tag	Application	Range
LIT01	Tank Level	0-100 psig

ULTRASONIC FLOWMETER

Output	4-20 mA	
Accuracy	±.5% of span	
Operating Temperature	-10 °F to 130 °F	
Measurement Range	.5 to 500 GPM	
Case Material	Epoxy Coated Ductile Iron Pipe	
Connection	3" Flange	
Power Supply	Battery Powered	
Display	Local LCD Display	
Suppliers	Master Meter Octave Ultrasonic Meter, Sensus Omni C2, or equal	
Instrument Tag	Application	Range
WM01	Water Meter	0 – 500 gpm

END OF SECTION

SECTION 26 90 50 – REMOTE TELEMETRY SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. It is the intention that under this specification, the Contractor shall furnish, install and place in successful operation a radio telemetry system between the pump station, the maintenance building and Headquarter building. The primary function of the radio system is to create a SCADA communication link from the pump station to the maintenance building for remote monitoring of the pump station and ground storage tank level and alarm to the Autodialer at the Headquarter building.

1.2 SCOPE

- A. The radio system shall be compatible with and operate on the 900MHz spread spectrum frequency range.
- B. The Contractor shall furnish services of qualified resources to:
 - 1. Conduct radio path study as required to confirm and/or determine all requirements for implementing complete and functional radio communication between the Pump Station to the maintenance building and the Headquarter building to the maintenance building.
 - 2. The Contractor shall install a new transmitter radio and yagi antenna at the Pump Station and Headquarter building and install a new transmitter radio and an omni antenna at the maintenance building. The radio shall be installed, connected, and configured as a remote telemetry unit to communicate SCADA information between the Pump Station and the maintenance building and communicate alarms information between the maintenance building to the Headquarter building.
- C. Programming of the radios and complete system functionality shall be the responsibility of the Contractor.
- D. All necessary wiring, installation, power up and broadcast testing to demonstrate reliable communication paths shall be provided by the Contractor for a complete installation. Upon the completion of equipment installation, calibration, and testing, the Contractor shall work hand-in-hand with the Owner/Engineer to assist start up and test all aspects of the control system as it pertains to this contract.
- E. This project consists of installation of communications and electrical equipment as detailed on the drawings. This includes related electrical items shown on the plans and specified herein and other sections of these specifications. All conduit and wire runs, wiring terminations, and equipment installation are to be performed by the Contractor.
- F. The installation shall comply with the applicable rules of the latest edition of the National Electrical Code, rules and regulations of the state building code, and local authorities having jurisdiction. In no case shall the materials and workmanship fail to meet the minimum requirements of the National Electrical Code.
- G. All materials used in this work shall be new and approved by the Underwriters' Laboratories in every case where they have established a standard for the particular type of material to be installed.
- H. Generally the work consists of, but is not limited to, installing, connecting, and testing the control panels, junction boxes, control systems, data acquisition equipment, and associated items to

complete the electrical systems so as to function as a whole. The Contractor shall demonstrate that the system operates properly and conforms to these Plans and Specifications.

- I. Any system varying from these specifications as to principle of operation, control and indication features or suitability for the particular application shall not be accepted.

1.3 RELATED SECTIONS:

- A. DIVISION 26 as it pertains to related electrical materials and installation.

1.4 REFERENCES

- A. Instrument Society of America
 1. ISA S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves
 2. ISA S50.1 - Compatibility of Analog Signals for Electronic Industrial Process Instruments
 3. ISA S51.1 - Process Instrumentation Terminology
 4. ISA S51.1; Sec. 5 - Test Procedures
- B. Definitions: Symbols, Definitions, and Abbreviations: All symbols, definitions, and engineering unit abbreviations utilized shall conform to IEEE 100-84, S50.1, and S51.1, where applicable.
 1. SCADA – Supervisory Control and Data Acquisition
 2. HMI – Human Machine Interface
 3. PLC – Programmable Logic Controller
 4. I/O – Input/Output
 5. RTU – Remote Telemetry Unit
 6. MTU – Master Telemetry Unit

1.5 SYSTEM REQUIREMENTS

- A. Performance Requirements:
 1. Radio Technical Resource:
 - a. The Contractor shall furnish the services of qualified radio technical personnel.
 - b. Radio technical personnel shall be highly qualified with a minimum of five (5) years experience working with radio telemetry system installation and configuration.
 - c. Selection of radio technical personnel working under this contract shall be approved by the Owner or Engineer.
 - d. Radio technical personnel shall provide a resume of past experience, with references, working with radio telemetry systems comparable in scope and equipment usage as the system specified in these plans and specifications.
 - e. Radio technical personnel shall provide copies of training and/or maintenance certifications.
 2. Radio Signal Fade Margin:
 - a. The radio signals received at all locations affected by this contract shall have fade margins of 20dB or better.
 3. Accuracy:
 - a. Accuracy shall be as defined in ISA S51.1 and ISA S51.1, Sec. 5.
 4. Ranges:
 - a. The expected range of each instrument shall be as shown on the drawings and as directed by the Owner and Engineer. Expected ranges shall correspond to actual field conditions.

1.6 PATENTS

- A. If the Manufacturer is required or desires to use any design, device, material, or process covered by letter, patent, or copyright, the Manufacturer shall provide for such use by suitable legal agreement with the patentee or owner, and the prices bid hereunder shall, without exception, indemnify and save the Owner and Engineer from any and all claims for infringement by reason of the use of any such patented design, device, material, or process, or any trademark or copyright used in connection with any equipment to be furnished hereunder.

1.7 SUBMITTALS

- A. Equipment installation details
- B. Equipment specification sheets
- C. Certified calibration sheets
- D. Complete and detailed instruction manuals on each item furnished including but not limited to all devices and instruments. Information to be contained in the instruction manuals shall include but not be limited to drawings, dimensions, manufacturer's recommendations, ratings, performance charts, power requirements, schematics, maintenance requirements and procedures, calibration recommendations and procedures, repair instructions, complete and recommended spare parts lists and related information.
- E. Proposed tagging and attachment materials and methods
- F. Fade margin test results
- G. Radio technical personnel resume and certifications as specified in SYSTEM REQUIREMENTS

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Storage and Protection: Delivery, storage, and handling shall be in accordance with Manufacturers' recommendation and the requirements of General Conditions and other sections herein.

1.9 PROJECT AND SITE CONDITIONS

- A. Environmental Requirements: Instrumentation and control elements will be installed outdoors exposed to sun, rain and excessive humidity and shall be capable of continuous operation without significant reduction of their operating life under the following ambient conditions:

Temperature	-25 °C to 80 °C
Pressure	650 mm Hg to 800 mm Hg
Relative Humidity	20% to 100% condensing
Vibration Frequency:	10 - 2000 Hz.

Vibration Position	1.5 mm peak-to-peak
Vibration Acceleration	10 G.

- B. Where the ratings of individual components cannot meet the requirements, provide suitable means of physical protection. Suitable physical protection shall consist of an assembly which meets the requirements listed, while limiting the ambient conditions at the non-conforming component to 90% of the component's rating (Example: A component rated for vibration at only 5 G. acceleration would be required to be combined with vibration isolation to limit the acceleration of the component to 4.5 G. when subjected to ambient acceleration of 10 G. from 10 - 2000 Hz.).
- C. Operating Environmental Conditions: All instruments and control devices provided shall be rated for continuous operation in their installed operating environment and shall be capable of continuous operation at the operating conditions without significant reduction of their operating life.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- A. Connect to instruments as specified in other portions of the drawings and contract documents.

2.2 RADIO TELEMETRY SYSTEM:

- A. Provide equipment including antenna, antenna coaxial cable, surge arrestors, enclosures, power supply, radio transceiver, auxiliary terminal blocks and wire markers, and connections as required by specifications and drawings. Provide testing, coordination of outages and all materials, methods and labor to demonstrate the reliable operation of the radio system.
- B. The Contractor shall place in satisfactory service a radio system which efficiently conveys data by radio-modem from the Booster Pump Station to the Water Treatment Plant. Radio systems shall be installed by a qualified radio system installer who holds all required licenses covering the installation and startup of the radio system and who meets the requirements of SYSTEM REQUIREMENTS. The installer shall have factory training or equivalent experience in startup and operation of the radio system specified.

2.3 ANTENNA

- A. Provide 900MHz weatherproof Yagi-type unit with minimum gain of 10dB, impedance of 50 ohms, VSWR of 1.5 to 1.0 or less, front to back ratio of greater than 15dB, maximum input power of 150W or greater, and wind survival rating of 125mph or higher. Antenna shall be as manufactured by PCTEL or approved equal. Furnish all mounting pipes and hardware for a complete antenna assembly.

2.4 ANTENNA LIGHTNING PROTECTION:

- A. Coaxial connection to the radio enclosure shall be by means of a coaxial type bulkhead lightning arrester with type N connections. The lightning arrester shall be rated at 1 kilowatt with a minimum 500V and maximum 2000V breakdown voltage. Coaxial lightning arrester shall be a PD-395 or PolyPhaser IS-B50LN.

2.5 DATA RADIO

- A. Furnish and install a data radio to be mounted inside 20CP01 control panel as depicted in the design documents. The radio shall meet FCC requirements for operation on unlicensed 900MHz frequency band. Provide a GE Orbit MCR-900, model number MXNX-U91-S2N or approved equal.

2.6 TRANSMISSION CABLE FOR RADIO:

- A. Provide weatherproof transmission cable, suitable for direct environmental exposure. Use "O" ring seals on connections.
- B. All connectors shall be type N.
- C. Provide suitable grounding kits for cable as manufactured by cable manufacturer. Grounding kits shall be located at the top and bottom of the support structure, and at 200ft intervals if structure is more than 200ft. Grounding kits shall be grounded to ground bars by a #2 solid copper jumper. Ground bars shall be grounded to each other and to the site's ground ring by #2 solid copper wire. Ground bar shall be Andrew Corp. UGBKIT-2 or approved equal.
- D. Provide a 6' section of "superflexible" transmission cable with appropriate connectors for routing within the RTU cabinet from the radio's antenna port to the enclosing cabinet's surge arrester connector. Superflex cable shall be Times Microwave LMR-195 or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. See specification 26 90 00 for general instrumentation equipment installation guidelines.

3.2 FINAL ACCEPTANCE TEST

- A. The Contractor shall conduct a 10 day Final Acceptance test of the completed installation for the equipment he furnishes and installs. The test shall start after the Engineer has received marked record (as-built) drawings from the Contractor and when directed by the Owner/Engineer.
- B. The system shall operate with 100 percent reliability during the test period. Failure shall be defined as the inability to control or indicate status of specified inputs or outputs or any specified function of the control systems as described herein caused by defective hardware or software furnished by the Contractor in this project. Failure of hardware or software shall require repair or remedy of the defect to the satisfaction of the Engineer within a two hour period. If the problem cannot be repaired in this time, the test shall be aborted and restarted after the problem is corrected and when directed by the Owner/Engineer. Restarting and satisfactory completion of the test shall be conducted at no additional cost to the Owner.
- C. The Contractor shall complete the Operations and Maintenance Manuals including all updated documentation of programmable devices to the satisfaction of the Engineer.
- D. The Contractor will be allowed two attempts at successfully completing the Final Acceptance Test. After that time, he will become responsible to reimburse the Owner for liquidated damages.

3.3 GUARANTEE

- A. The Contractor shall furnish a written certificate guaranteeing materials, equipment, and labor furnished by him, to be free of defects for one (1) year from date of final acceptance, and shall further guarantee that should any defects appear within this period, same will be replaced or made good without charge.
- B. Upon completion of the installation, the Contractor shall adjust the systems to the satisfaction of the Engineer.
- C. This guarantee shall include the capacity and integrated performance of the component parts of the various systems in accordance with the intent of the specifications. The Contractor shall conduct complete tests required by the Engineer to demonstrate the ability of the various systems.

END OF SECTION

DIVISION 31
EARTHWORK

SECTION 31 11 00 - SITE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Clearing, grubbing, scalping, stripping, and disposal of waste debris.

1.2 DEFINITIONS

- A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.
- B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.
- C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 inches caliper to a depth of 12 inches below subgrade.
- D. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.
- E. Stripping: Removal of topsoil remaining after applicable scalping is completed.
- F. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.3 SUBMITTALS

- A. Shop Drawings: Drawings clearly showing clearing, grubbing, and stripping limits.

1.4 QUALITY ASSURANCE

- A. Obtain Engineer's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.5 SCHEDULING AND SEQUENCING

- A. Prepare site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of 5 acres.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or site improvements within limits shown or specified.
- B. Do not injure or deface vegetation that is not designated for removal.

3.2 LIMITS

- A. As follows, but not to extend beyond Project limits.
 - 1. Excavation, including trenches, 5 feet beyond top of cut slopes or shored walls.

2. Fill:
 - a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
 - b. Stripping and Scalping: 2 feet beyond toe of permanent fill.
3. Structures: 15 feet outside of new structures.
4. Roadways: Clearing, grubbing, scalping, and stripping 15 feet from centerline.
5. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.3 CLEARING

A. Clear areas within limits shown or specified.

B. Fell trees so that they fall away from facilities and vegetation not designated for removal.

C. Cut stumps not designated for grubbing to within 6 inches of ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.4 GRUBBING

A. Grub areas within limits shown or specified.

3.5 SCALPING

A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed.

B. Scalp areas within limits shown or specified.

3.6 STRIPPING

A. Do not remove topsoil until after scalping is completed.

B. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.

C. Stockpile strippings, meeting requirements for topsoil, separately from other excavated material.

3.7 TOPSOIL

A. Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1-1/2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

3.8 DISPOSAL

A. Clearing and Grubbing Debris:

1. Dispose of debris.

2. Burning of debris will not be allowed.

3. Woody debris may be chipped. Chips may be sold to Contractor's benefit or used for landscaping as mulch or uniformly mixed with topsoil, provided that resulting mix will be fertile and not support combustion. Maximum dimensions of chipped material used shall be 1/4-inch by 2 inches. Dispose of chips that are unsaleable or unsuitable for landscaping or other uses with unchipped debris.

4. Limit disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.
- B. Scalpings: As specified for clearing and grubbing debris.
- C. Strippings:
1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil
 2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

SECTION 31 22 13 - SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work and testing required for preparing subgrade.
- B. Related sections:
 - 1. Section 31 11 00 – Site Preparation.
 - 2. Section 31 23 16 – Excavation.
 - 3. Section 31 23 23.13 – Fill and Backfill.

1.2 REFERENCE STANDARDS

- A. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³)
- B. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³)

1.3 DEFINITIONS

- A. Optimum Moisture Content: As defined in Section 31 23 23.13, Fill and Backfill.
- B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.
- C. Relative Compaction: As defined in Section 31 23 23.13, Fill and Backfill.
- D. Relative Density: As defined in Section 31 23 23.13, Fill and Backfill.
- E. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.
- F. Standard Specifications: The latest edition, including supplements of the Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

1.4 SEQUENCING AND SCHEDULING

- A. Complete applicable Work specified in Sections 02 41 00, Demolition; 31 11 00, Site Preparation; and 31 23 16, Excavation, prior to preparation.

1.5 QUALITY ASSURANCE

- A. Notify Engineer when subgrade is ready for compaction or whenever compaction is resumed after a period of extended inactivity.

1.6 ENVIRONMENTAL REQUIREMENTS

- A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.
- B. Bring subgrade to proper grade and cross-section and uniformly compact surface.
- C. Do not use sections of prepared ground surface as haul roads. Protect prepared from traffic.
- D. Maintain prepared ground surface in finished condition until next course is placed.

3.2 MOISTURE CONDITIONING

- A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.
- B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.3 TESTING

- A. Test roll subgrade as specified in Standard Specifications to detect soft or loose subgrade or unsuitable material, as determined by Engineer.

3.4 CORRECTION

- A. Soft or Loose Subgrade:
 - 1. Adjust moisture content and recompact, or
 - 2. Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23.13, Fill and Backfill.

END OF SECTION

SECTION 31 22 19 - GRADING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Removal and storage of topsoil.
 - 2. Rough grading the site for site structures, building pads, and drive and parking isles.
 - 3. Finish grading for planting.
- B. Related sections:
 - 1. Section 31 23 16 – Excavation.
 - 2. Section 31 23 23.13 – Fill and Backfill.
 - 3. Section 31 23 16.16 – Trenching for Water and Sewer Lines.

1.2 SUBMITTALS

- A. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.3 QUALITY ASSURANCE

- A. Perform Work in accordance with Texas Department of Transportation standards.
 - 1. Maintain one copy on site.

1.4 PROJECT CONDITIONS

- A. Protect above – and below – grade utilities that remain.
- B. Protect plants, lawns, rock outcroppings, and other features to remain as a portion of final landscaping.
- C. Protect benchmarks, survey control points, existing structures, fences, sidewalks, paving and curbs from grading equipment and vehicular traffic.

PART 2 - PRODUCTS

2.1 MATERIALS.

- A. Topsoil: Shall be soil suitable for sustaining grass and vegetation and shall not have any particles larger than $\frac{3}{4}$ " in diameter and shall be free of any trash, debris, or deleterious material.
- B. Other Fill Materials: See Section 31 23 23.13, Fill and Backfill.

PART 3 - EXECUTIONS

3.1 EXAMINATION

- A. Verify that survey benchmark and intended elevations for the Work are as indicated.

3.2 PREPARATION

- A. Identify required lines, levels, contours, and datum.

- B. Stake and flag locations of known utilities.
- C. Locate, identify, and protect utilities that remain from damage.
- D. Notify utility company to remove and relocate utilities.

3.3 ROUGH GRADING

- A. Remove topsoil from areas to be further excavated, re-landscaped, or re-graded without mixing with foreign materials.
- B. Do not remove topsoil when wet.
- C. Remove subsoil from areas to be further excavated, re-landscaped, or re-graded.
- D. Do not remove wet subsoil, unless it is subsequently processed to obtain optimum moisture content.
- E. When excavating through roots, perform work by hand and cut roots with sharp axe.
- F. Stability: Replace damaged or displaced subsoil to same requirements as for specified fill.

3.4 SOIL REMOVAL

- A. Stockpile excavated topsoil on site.
- B. Stockpile excavated subsoil on site.
- C. Stockpiles: Use areas designated on site; pile depth not to exceed 8 feet; protect from erosion.

3.5 FINISH GRADING

- A. Before Finish Grading:
 1. Verify building and trench backfilling have been inspected.
 2. Verify subgrade has been contoured and compacted.
- B. Remove debris, roots, branches, stones, in excess of ½ inch in size. Remove soil contaminated with petroleum products.
- C. In areas where vehicles or equipment have compacted soil, scarify surface to depth of 3 inches.
- D. Place topsoil in areas where seeding is indicated.
- E. Place topsoil to the following compacted thicknesses:
 1. Areas to be Seeded with Grass: 6 inches.
 2. Areas to be Sodded: 4 inches.
 3. Shrub Beds: 18 inches.
 4. Flower Beds: 12 inches
 5. Planter Boxes: To within 3 inches of box rim.
- F. Place topsoil during dry weather.
- G. Remove roots, weeds, rocks, and foreign material while spreading.
- H. Near plants spread topsoil manually to prevent damage.

- I. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of subgrade.
- J. Lightly compact placed topsoil.

3.6 TOLERANCES

- A. Top Surface of Subgrade: Plus or minus 1/10 foot from required elevation.
- B. Top Surface of Finish Grade: Plus or minus ½ inch.

3.7 FIELD QUALITY CONTROL

- A. See Section 31 23 23.13, Fill and Backfill, for compaction density testing.

3.8 CLEANING AND PROTECTION

- A. Remove unused stockpiled topsoil and subsoil. Grade stockpile area to prevent standing water.
- B. Leave site clean and raked, ready to receive landscaping.

END OF SECTION

SECTION 31 23 16 - EXCAVATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work and materials associated with excavation.
- B. Related sections:
 - 1. Section 31 11 00 – Site Preparation.

1.2 SUBMITTALS

- A. Shop Drawings:
 - 1. Excavation Plan, Detailing:
 - a. Methods and sequencing of excavation.
 - b. Proposed locations of stockpiled excavated material.
 - c. Proposed and spoil disposal sites.
 - d. Numbers, types, and sizes of equipment proposed to perform excavations.

1.3 QUALITY ASSURANCE

- A. Provide adequate survey control to avoid unauthorized over-excavation.

1.4 WEATHER LIMITATIONS

- A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.
- B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.5 SEQUENCING AND SCHEDULING

- A. Demolition: Complete demolition of existing piping as required after new connections are made.
- B. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 11 00, Site Preparation, prior to excavating.
- C. Dewatering: Dewatering prior to initiating excavation.
- D. Excavation Support: Install and maintain, as specified in Section 31 50 00, Excavation Support Systems as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1-foot except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base,

topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

- B. Do not over excavate without written authorization of Engineer.
- C. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls.

3.2 UNCLASSIFIED EXCAVATION

- A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

3.3 TRENCH WIDTH

- A. Minimum Width of Trenches:
 - 1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
 - a. Less than 4-inch Outside Diameter or Width: 18 inches.
 - b. Greater than 4-inch and up to 18-inch Outside Diameter or Width: 12 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
 - c. Greater than 18-inch Diameter or Width: 24-inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
 - 2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
 - 3. Increase trench widths by thicknesses of sheeting.
- B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.4 PIPE BEDDING GROOVES FOR NONPERFORATED DRAIN LINES

- A. Semicircular, trapezoidal, or 90-degree-V.
- B. Excavated or plowed into trench bottom. Forming groove by compaction will not be acceptable.

3.5 STOCKPILING EXCAVATED MATERIAL

- A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.
- B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.
- C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.
- D. Do not stockpile excavated material adjacent to trenches and other excavations unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.
- E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.6 DISPOSAL OF SPOIL

- A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill,
- B. Dispose of debris resulting from removal of underground facilities at appropriate landfill unless otherwise allowed by Owner.
- C. Dispose of debris resulting from removal of organic matter, trash, refuse, and junk as specified in Section 31 11 00, Site Preparation, for clearing and grubbing debris.

3.7 EXCAVATION SAFETY

- A. Conform to all applicable federal, state, and local regulations.

3.8 SUBGRADE PREPARATION

- A. The excavation for all structures and facilities shall be in dewatered, firm, undisturbed earth. Excavation shall extend down to the levels required to construct the facilities.
- B. The subgrade soils at the base of the excavations shall be proofrolled to detect any areas of weakness. Proofrolling shall be performed in accordance with the Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, 2014 Edition, Item 216, Proofrolling.
- C. Proofrolling operations will be observed by a Professional Geotechnical Engineer or Professional Geologist licensed in the State of Texas and retained by the Owner.
- D. Any soft or compressible areas detected during proofrolling shall be over-excavated until firm soil is exposed. Low areas resulting from over-excavation shall be filled select fill in compacted lifts. The select fill is to be placed in lifts not to exceed 8 inches in uncompacted depth. Each lift is to be compacted to a minimum of 95% of maximum density in accordance with ASTM D698 at a moisture content within three percentage points ($\pm 3\%$) of optimum moisture content.
- E. Once all low areas are filled in, the exposed subgrade is to be scarified to a depth of 8 inches and have its moisture content adjusted and be recompacted to the limits listed below.
 - 1. For soils having a plasticity index (PI) of 15 or less, recompact to a minimum of 95% of maximum density as defined by ASTM D698 at a moisture content within $\pm 3\%$ of the optimum moisture content.
 - 2. For soils having a PI between 16 and 25, recompact to a minimum of 95% of maximum density as defined by ASTM D698 at a moisture content ranging from -1% to 5% of the optimum moisture content.
 - 3. For soils having a PI greater than 25, recompact to between 95% and 100% of maximum density as defined by ASTM D698 at a moisture content ranging from 1% to 6% above the optimum moisture content.
- F. After an acceptable subbase has been prepared, it is to be covered by a 3-inch concrete mud slab within 24 hours of establishing the acceptable subbase. If rain occurs prior to the mud slab being placed, the subbase shall be dried to the moisture contents listed above and recompacted as required.
- G. The mud slab is to be constructed of minimum $f'c = 3000$ psi concrete. The mud slab is to be sloped at a minimum grade of 1% to one or more collection points where rainwater runoff is to be collected and pumped out of the excavation.

- H. Any disturbance of the accepted subbase prior to the installation of the mud slab must be remediated by removing the disturbed area and filling with select fill as described in this section.
- I. If the source of the disturbance is determined to be the result of the actions, or inactions of the Contractor, (for example, inadequate dewatering, disturbance by excavating or hauling equipment) the cost of additional subgrade preparation will be at the Contractor's expense.

END OF SECTION

SECTION 31 23 16.16 – TRENCHING FOR WATER AND SEWER LINES

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes excavation required for the construction of water and sewer pipes and appurtenances.
- B. Related sections:
 - 1. Section 31 23 23.19 – Trench Bedding and Backfill for Water and Sewer Lines
 - 2. Section 33 41 19 – Pipe Laying

1.2 GENERAL

- A. General Requirements: See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the work specified herein and are mandatory for this project.
- B. Provide and install trench bracing and shoring that conforms to the requirements of 29 CFR Part 1926 Subpart P of the OSHA Standards. Bracing shall be so arranged as not to place any strain on portions of completed work until the construction has proceeded far enough to provide ample strength.
- C. Overexcavation, whether by Contractor's negligence or at direction of the Engineer, shall be repaired to required lines and grades.
- D. Trenches shall be dug to the alignment and depth required and shall not advance more than 100 feet ahead of the completed pipe, unless otherwise permitted by the Engineer.

1.3 UTILITIES

- A. Contractor shall call "Texas811" a minimum of two working days before starting excavation. The ONE CALL phone number is 1-800-344-8377.
- B. The location and/or elevation of existing utilities as shown on these plans is based on records of the various utility companies and, where possible, measurements taken in the field. The information is not to be relied upon as being exact or complete. The Contractor must call each utility owner at least two working days before any excavation to request exact field location of utilities.
- C. Protect utilities encountered during excavation.
- D. Do not interrupt service in utilities encountered during excavation without approval of the utility owner.
- E. If utilities are damaged or utility service is interrupted by work under this section, the utility owner has the first right to repair. If public health or safety is at risk, Contractor shall take appropriate prudent action to repair damage and service interruption. Costs of utility protection and repair shall be at no additional cost to the Owner.
- F. If existing utilities are found to interfere with the permanent facility being constructed, notify the Engineer for instructions. Do not proceed with permanent relocation of utilities without written instructions from the Engineer.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

- A. Shall be as specified in Section 31 23 23.19, TRENCH BEDDING AND BACKFILL FOR WATER AND SEWER LINES.

PART 3 - EXECUTION

3.1 GENERAL

- A. Notify property residents two working days prior to beginning excavation on property.
- B. Excavated materials not suitable for backfill or embankment shall not be incorporated into the project but shall be disposed of by Contractor.
- C. Excavate with caution so that structures and underground conduits can be protected.
- D. Excavate every type of material encountered to the lines and elevations necessary to complete the project.
- E. Reroute surface water before excavating and protect excavated trench from entrance of surface water.
- F. In general, the sheeting and bracing shall be removed as the trench or excavation is backfilled, and in such a manner as to avoid the caving in of the bank or disturbance of adjacent areas or structures. The voids left by the withdrawal of sheeting shall be backfilled the same as trench excavations.
- G. Provide "before and after" color photographs of lawns and gardens to Engineer.
- H. Comply with Section 33 41 19, PIPE LAYING.

3.2 TRENCH DEPTH

- A. Excavate to the elevation necessary to provide the depth of bedding material under the barrel of the pipe, noted on the plans or in these specifications, whichever is greater.
- B. All over-excavation up to 2 feet shall be backfilled with bedding material in 6-inch layers and tamped to a bearing capacity equal to the adjacent undisturbed earth. Over excavation greater than 2 feet will require excavation operation to stop until an engineered backfill is determined. Over excavation shall not proceed until approved by Engineer. Contractor shall bear all expense involved if he fails to obtain prior approval from the Engineer.

3.3 TRENCH WIDTH

- A. Excavate to the width shown in detail drawings. Specified width dimensions must be maintained from trench bottom to an elevation 12 inches above barrel of pipe. Over-width excavation will require excavation operation to stop until additional earth loads can be compared to strength of pipe. Costs of unauthorized deviation from the specified width will be borne by the Contractor.

3.4 TRENCH LENGTH

- A. Excavate to a maximum distance of 100 feet from the pipe jointing operation. Longer distances will be considered when conditions warrant.

3.5 EXCAVATION IN ROCK

- A. When rock is encountered, excavate to an elevation 6 inches below the pipe and to the trench width as shown in the details at no additional cost to Owner.

3.6 EXCAVATION IN UNSUITABLE SOIL

- A. Where, in the judgment of the Engineer, the planned bottom of trench is found to be unstable, excavation shall stop until an engineered subgrade stabilization method is determined.

3.7 EXCAVATION IN WET CONDITIONS

- A. Where the planned bottom of trench contains water or the trench bottom is soft from excess water, excavation depth shall increase a minimum of 6 inches or as directed by the Engineer.

3.8 EXCAVATION IN UNFORESEEN STRUCTURE

- A. Preserve unforeseen structures encountered in excavation.
- B. Advise the Engineer when unforeseen structure interferes with planned work. Engineer will determine if plan will change or if structure will be abandoned.

3.9 UNAUTHORIZED EXCAVATION

- A. Unauthorized excavation is removal of materials beyond specified elevations or dimensions without the Engineer or Owner's specific prior approval.

3.10 UNSUITABLE AND EXCESS EXCAVATED MATERIAL:

- A. Excavated material not suitable for backfill and excess excavated material shall be disposed of by Contractor in a manner approved by the Engineer and applicable governmental regulations.

3.11 EXCAVATION DEWATERING:

- A. Wellpointing or deep wells, where required to keep the excavation dry and the subgrade stable, shall be installed when the excavation extends to within two (2) feet of the water table, except as herein provided, and shall be in continuous operation until backfill is completed to this level.
- B. When construction equipment is to be operated in an area that has been excavated, and wellpointing or deep wells are required to keep the excavation dry and the subgrade stable, the wellpointing or deep wells shall be installed when the excavation extends to within five (5) feet of the water table.
- C. There shall be sufficient pumping equipment, in good working order, readily available at all times to remove any water that accumulates in excavations to the extent that a stable subgrade is obtained.
- D. Where the excavation crosses natural drainage channels, the work shall be conducted in such a manner that unnecessary damage or delays in the prosecution of the work will be prevented.

- E. Trench dewatering shall discharge to an approved location in conformance with the Stormwater Pollution Prevention Plan.
- F. Wellpoint dewatering for the sewer line construction will not be mandatory where a properly stabilized subgrade can be obtained by use of granular bedding. If granular bedding is utilized by the Contractor for stabilization of the trench bottom in lieu of wellpointing, such bedding material will not be measured for separate payment but will be considered subsidiary to the pipe installation.
- G. Where dewatering might be necessary to properly install the sewer line, such as at drainage channel crossings and tunnel or boring locations, the Contractor shall submit his proposal for this dewatering to the Owner for approval.
- H. Dewatering operations shall continue until pipe has been backfilled and a sufficient cover depth has been reached to prevent flotation of pipe.

END OF SECTION

SECTION 31 23 23.13 - FILL AND BACKFILL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work and materials required for fill and backfill for all excavations other than trench type excavations.
- B. Related sections:
 - 1. Section 03 30 00 – Cast-In-Place Concrete.
 - 2. Section 31 11 00 – Site Preparation.
 - 3. Section 31 22 13 – Subgrade Preparation.
 - 4. Section 31 23 16 – Excavation.
 - 5. Section 31 23 23.19 – Trench Bedding and Backfill for Water and Sewer Lines.
 - 6. Section 32 11 00 – Base Course.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Society for Testing and Materials (ASTM):
 - a. ASTM C117, Standard Test Method for Materials Finer Than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing.
 - b. ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - c. ASTM D75, Standard Practice for Sampling Aggregates.
 - d. ASTM D698, Standard Test Methods for Laboratory Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
 - e. ASTM D1556, Standard Test Method for Density of Soil in Place by the Sand Cone Method.
 - f. ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³).
 - g. ASTM D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
 - h. ASTM D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - i. ASTM D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - 2. Texas Department of Transportation
 - a. Standard Specification for Construction and Maintenance of Highways, Streets and Bridges, 2014 Edition.

1.3 DEFINITIONS

- A. Relative Compaction:
 - 1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D1557.
 - 2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.
- B. Optimum Moisture Content:
 - 1. Determined in accordance with ASTM D1557 specified to maximum dry density for relative compaction.
 - 2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

- C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.
- D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and preparation.
- E. Completed Course: A course or layer that is ready for next layer or next phase of Work.
- F. Lift: Loose (uncompacted) layer of material.
- G. Geosynthetics: Geotextiles, geogrids, or geomembranes.
- H. Well-Graded:
 - 1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
 - 2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
 - 3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.
- I. Influence Area: Area within planes sloped upward and/or downward and outward at 45-degree angle from horizontal measured from: (Add No. 3)
 - 1. 1-foot outside outermost edge at base of foundations or slabs.
 - 2. 1-foot outside outermost edge at surface of roadways or shoulder.
 - 3. 0.5-foot outside exterior at spring line of pipes or culverts.
- J. Borrow Material: Material from required excavations or from designated borrow areas on or near site.
- K. Selected Backfill Material/Earth fill: Materials available onsite that Engineer determines to be suitable for specific use.
- L. Imported Material: Materials obtained from sources suitable for specified use.
- M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.
- N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.
- O. Standard Specifications: When referenced in this section, shall mean the latest edition of the Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

1.4 SUBMITTALS

- A. Quality Control Submittals:
 - 1. Catalog and manufacturer's data sheets for compaction equipment.
 - 2. Certified test results from independent testing agency.

1.5 QUALITY ASSURANCE

- A. Notify Engineer when:
 - 1. Structure is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.

2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

1.6 SEQUENCING AND SCHEDULING

- A. Complete applicable Work specified in 31 11 00, Site Preparation; 31 23 16, Excavation; and 31 22 13, Subgrade Preparation, prior to placing fill or backfill.
- B. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03 30 00, Cast-In-Place Concrete. Obtain acceptance of concrete work and attained strength prior to placing backfill.
- C. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03 30 00, Cast-In-Place Concrete.
- D. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 22 13, Subgrade Preparation.

PART 2 - PRODUCTS

2.1 SOURCE QUALITY CONTROL

- A. Gradation Tests: It will be the Contractor's responsibility to conduct testing as necessary to locate acceptable sources of imported material.

2.2 EARTH FILL

- A. Excavated material from required excavations, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.
- B. Earth fill shall not be used beneath any slab-on-grade or equipment pad. Use granular fill, as defined below.

2.3 GRANULAR FILL

- A. Type A or D, Grade 1 or 2 aggregate meeting all the requirements of Section 247 of the Standard Specifications.

2.4 GRANULAR DRAINAGE

- A. ASTM D448/C33 Gradation Class 56.

2.5 SELECT FILL

- A. On site or imported soils, free of organic matter or rock larger than 2 inches. Plasticity Index (PI) to be between 5 and 15, liquid limit less than 35, and a maximum of 45% passing the No. 200 sieve.

2.6 FLOWABLE FILL

- A. As specified in Section 31 23 23.33, Flowable Fill.

2.7 WATER FOR MOISTURE CONDITIONING

- A. Free of hazardous or toxic contaminants, or contaminants deleterious to proper compaction.

2.8 BASE COURSE ROCK

- A. As specified in Section 32 11 00, Base Course.

2.9 FOUNDATION STABILIZATION ROCK

- A. Crushed rock or pit run rock.
- B. Uniformly graded from coarse to fine.
- C. Free from excessive dirt and other organic material.
- D. Maximum 2-1/2 inches particle size.

PART 3 - EXECUTION

3.1 GENERAL

- A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.
- B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.
- C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.
- D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.
- E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:
 1. Fill or backfill to an elevation 2 feet above top of item to be laid.
 2. Excavate trench for installation of item.
 3. Install bedding, if applicable, as specified in Section 31 23 23.16, Trench Backfill.
 4. Install item.
 5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.16, Trench Backfill, before resuming filling or backfilling specified in this section.
- F. Tolerances:
 1. Final Lines and Grades: Within a tolerance of 0.1-foot unless dimensions or grades are shown or specified otherwise.
 2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.
- G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.
- H. Fill and backfill materials shall be conditioned to a water content that is within 2 percentage points (plus or minus) of the optimum required for compaction as determined by ASTM D1557.

3.2 BACKFILL UNDER AND AROUND STRUCTURES

- A. Under Facilities: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with granular fill, unless otherwise shown. Place granular fill in lifts of 6-inch maximum thickness and compact each lift to minimum of 98 percent of its maximum dry density as determined by ASTM D1557 (modified proctor).
- B. Subsurface Drainage: Backfill with granular drainage material, where shown on drawings. Place granular drain material in lifts of 6-inch maximum thickness and compact each lift to minimum of 90 percent of its maximum dry density as determined by ASTM D1557 (modified proctor).
- C. Other Areas: Backfill with earthfill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 6-inch maximum thickness and compact each lift to minimum of 95 percent of its maximum dry density as determined by ASTM D1557 (modified proctor).

3.3 FILL

- A. Outside Influence Areas Beneath Structures, Tanks, Pavements, Curbs, Slabs, and Other Facilities: Unless otherwise shown, place earthfill as follows:
 - 1. Allow for 6-inch thickness of topsoil where required.
 - 2. Maximum 9-inch thick lifts.
 - 3. Place and compact fill across full width of embankment.
 - 4. Compact to minimum of 98 percent of its maximum dry density as determined by ASTM D1557 (modified proctor).
 - 5. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

3.4 SITE TESTING

- A. Gradation:
 - 1. One sample from each 400 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from Specifications.
 - 2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
 - 3. Remove material placed in Work that does not meet Specification requirements.
- B. In-Place Density Tests: In accordance with ASTM D1556, or ASTM D6938. During placement of materials, test as follows:
 - 1. One test per every other lift per 200 lineal feet of roadway or trench.
 - 2. A minimum of two tests on granular fill beneath structures.
 - 3. A minimum of two test per 300 cubic yards during backfilling of walls.
- C. Testing of placed material shall be performed by the Owner's subcontractor. It shall be the Contractor's responsibility to replace any material not meeting test requirements at no cost to the Owner.

3.5 GRANULAR BASE, SUBBASE, AND SURFACING

- A. Place and Compact as specified in Section 32 11 00, Base Course.

3.6 REPLACING OVEREXCAVATED MATERIAL,

- A. Replace excavation carried below grade lines shown or established by Engineer as follows:

1. Beneath Footings: Concrete of strength equal to that of respective footing.
2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
3. Beneath Slabs-On-Grade: Granular fill.
4. Trenches:
 - a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe bedding material, as specified in Section 31 23 23.16, Trench Backfill.
 - b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.16, Trench Backfill.
5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
 - a. Flat to Moderate Steep Slopes (3:1, Horizontal Run:Vertical Rise or Flatter): Earthfill.
 - b. Steep Slopes (Steeper than 3: 1):
 - 1) Correct overexcavation by transitioning between areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
 - 2) Backfilling overexcavated areas is prohibited unless, in opinion, backfill will remain stable, and overexcavated material is replaced as compacted earth fill.

END OF SECTION

SECTION 31 23 23.19 – TRENCH BEDDING AND BACKFILL FOR WATER AND SEWER LINES

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes materials and work required for placing bedding and backfilling of water and sewer pipelines and appurtenances.
- B. Related sections:
 - 1. Section 33 41 19 – Pipe Laying

1.2 GENERAL

- A. General Requirements: See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

1.3 DEFINITIONS

- A. Base Rock: Granular material upon which manhole bases and other structures are placed.
- B. Bedding Material: Granular material which is used as fill material in the pipe zone of the trench.
- C. Backfill Material: Material used to fill pipe trench from the upper surface of the pipe zone to existing grade or bottom of proposed pavement section.
- D. Imported Material: Material obtained by the Contractor from source(s) offsite.
- E. Lift: Loose (uncompacted) layer of material.
- F. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe or bedding material.
- G. Prepared Trench Bottom: Graded trench bottom after stabilization and installation of bedding material.
- H. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698, Corrections for oversize material may be applied to either the as-compacted field dry density or the maximum dry density, as determined by the Engineer.
- I. Relative Density: As defined by ASTM D4253 and ASTM D4254.
- J. Selected Backfill Material: Material available that the Engineer determines to be suitable for a specific use.
- K. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Well-Graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.

1.4 SUBMITTALS

- A. Quality Control Submittals
 - 1. Catalog and manufacturer's data sheets for compaction equipment.
 - 2. Certified test results from independent testing agency.
 - 3. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to site.

1.5 QUALITY ASSURANCE

- A. Notify Engineer when:
 - 1. Soft or loose subgrade materials are encountered wherever pipe bedding is to be placed.
 - 2. Fill material appears to be deviating from Specifications.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Backfill materials shall be obtained from excavated materials or approved borrow sources.
- B. Backfill material shall be free of trash, debris, cinders, organic matter or other deleterious materials.
- C. All backfill materials shall be subject to the Engineer's approval.

2.2 TRENCH STABILIZATION MATERIAL

- A. Clean, hard, durable 3-inch minus crushed rock gravel, or pit run, free from clay balls, other organic materials, or debris.
- B. Uniformly graded from coarse to fine, less than 8 percent by weight passing the 1/4-inch sieve.

2.3 BEDDING MATERIAL AND PIPE ZONE MATERIAL

- A. Unfrozen, friable, and no clay balls, roots, or other organic material.
- B. Pipe bedding shall be in accordance with ASTM C33, gradation 67, commonly known as ASTM #67. The gradation shall be as follows:

ASTM #67 Gradation	
Sieve Size	Percent Passing
1 in.	100
3/4 in.	90-100
3/8 in.	20-55
No. 4	0-10
No. 8	0-5

- C. Alternative bedding materials may be considered at the discretion of the Engineer. Alternate bedding materials shall be crushed rock classified as GP as specified in ASTM D2487 with 15% sand or less, a maximum of 25% passing 3/8-inch sieve, and a maximum of 5% fines.

2.4 TRENCH BACKFILL - GENERAL

- A. Excavated material from required excavations, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

2.5 TRENCH BACKFILL – GRANULAR

- A. Granular backfill shall be placed under all existing or proposed driving surfaces and/or as specified on the Plans.
- B. Granular backfill shall be Type A, Grade 3 or better crushed limestone base material meeting all the requirements of Item 247 of the Texas Department of Transportation Standard Specifications.

2.6 TOPSOIL

- A. Topsoil removed and stockpiled from onsite excavation.
- B. Should the Contractor dispose of existing topsoil the Contractor shall acquire and place topsoil to a minimum 6-inch depth at no additional cost to the Owner.

PART 3 - EXECUTION

3.1 GENERAL

- A. All bedding material shall be placed in accordance with Section 33 41 19.
- B. Process excavated material to meet specified gradation requirements.
- C. Adjust moisture content as necessary to obtain specified compaction.
- D. Do not allow backfill to free fall into the trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over the top of pipe.
- E. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
- F. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
- G. Backfill around structures with same class backfill as specified for adjacent trench unless otherwise shown or specified.

3.2 TRENCH BACKFILL-GENERAL

- A. Trench backfill shall be placed in in lift not exceeding 9-inch thickness.
- B. Each lift shall be mechanically compacted to a minimum of 95 percent relative compaction prior to placing succeeding lifts.

3.3 TRENCH BACKFILL-GRANULAR

- A. Granular backfill shall be used under all existing or proposed driving surfaces and at locations specified on the Plans.
- B. Granular backfill shall be placed in lifts not exceeding 8-inch thickness.
- C. Each lift shall be mechanically compacted to 95 percent relative compaction prior to placing succeeding lifts.

3.4 REPLACEMENT OF TOPSOIL

- A. Replace topsoil in top 6 inches of backfilled trench.
- B. Maintain the finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.5 MAINTENANCE OF TRENCH BACKFILL

- A. After each section of trench is backfilled, maintain the surface of the backfilled trench even with the adjacent ground surface until final surface restoration is completed.
- B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep the surface of the backfilled trench even with the adjacent ground surface, and grade and compact as necessary to keep the surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.
- C. Topsoil: Add topsoil where applicable and as necessary to maintain the surface of the backfilled trench level with the adjacent ground surface.
- D. Concrete Pavement: Replace settled areas or fill with concrete as specified in Section 32 13 13.
- E. Other Areas: Add excavated material where applicable and keep the surface of the backfilled trench level with the adjacent ground surface.

3.6 SETTLEMENT OF BACKFILL

- A. Settlement of trench backfill, or of fill or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

END OF SECTION

SECTION 31 23 23.33 – FLOWABLE FILL

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies controlled low strength concrete flowable fill.
- B. Comply with all requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE except as specifically modified in this Section.
- C. Related sections:
 - 1. Section 03 30 00 - Cast-In-Place Concrete.

1.2 DEFINITIONS

- A. Flowable Fill: Controlled low strength concrete ready mix.

1.3 SUBMITTALS

- A. Comply with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

1.4 QUALITY ASSURANCE

- A. Comply with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

PART 2 - PRODUCTS

2.1 PRODUCTS

- A. Comply with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE and as follows:
 - 1. Concrete Mixture for Flowable Fill only:
 - a. Compressive strength 75 to 100 psi.
 - b. Cement 80-100 lbs per CY.
 - c. Fly Ash 200-300 lbs per CY.
 - d. Sand variable to equal one CY.
 - e. Water 65 to 199 gallons per CY.
 - f. Unit weight approximately 110 lbs/CY.

PART 3 - EXECUTION

3.1 EXECUTION

- A. Comply with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

END OF SECTION

SECTION 31 32 00 - SOIL EROSION STABILIZATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work and materials required to minimize erosion and comply with Storm Water Pollution Prevention Plan.

1.2 STABILIZATION

- A. Soil Erosion Stabilization:
 - 1. Ground surfaces exposed during the wet weather conditions:
 - 2. Areas which will not be subjected to heavy wear by ongoing construction traffic.
 - 3. Temporary and long-term stabilization of new or disturbed ditches, swales, detention ponds, or disturbed ground with intermittence construction traffic.
- B. Permanent Stabilization:
 - 1. Permanently stabilize exposed soil surfaces at finished grades.
 - 2. Permanent stabilization methods include, but are not limited to, seeding (permanent), mulching, and landscaping.
 - 3. Immediately perform permanent stabilization at each completed excavation and areas except for areas that are scheduled to be redisturbed.
 - 4. Incorporate all permanent erosion control features into the project at the earliest practical time.
- C. Buffer Zone: Undisturbed area or strip of natural vegetation or an established suitable planting adjacent to a disturbed area that reduces erosion and runoff.
- D. Standard Specifications: The latest edition, including supplements, of the Texas Department of Transportation Standard Specifications for Highway Construction.

1.3 SUBMITTALS

- A. Shop Drawings: Product Data for the following items:
 - 1. Erosion control rock.
 - 2. Fertilizer.
 - 3. Seed.
 - 4. Mulch.
 - 5. Erosion control rock.
 - 6. Soil tackifier
 - 7. Reinforced plastic covering.
 - 8. Silt fence.
 - 9. Straw bales.
 - 10. Posts for straw bales.
 - 11. Dust controller.
 - 12. Wire mesh.

1.4 DELIVERY, STORAGE, AND PROTECTION

- A. General: Prevent or reduce the discharge of pollutants to stormwater from all material delivery and storage by minimizing the storage of hazardous materials storing materials in a designated area, installing Secondary containment, conducting regular inspection, and training employees and subcontractors.

- B. Seed:
 - 1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
 - 2. Keep dry during storage.
- C. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.5 SEQUENCING AND SCHEDULING

- A. Install erosion and sediment control devices before starting earth disturbance activities and as drainage facilities get constructed.
- B. Complete Soil Preparation: Seeding, fertilizing, mulching and matting on disturbed areas that will require stabilization either because the area has reached final grade (permanent landscaping) or because the area will remain unworked for over 14 days (temporary seeding) during the wet season.
- C. Notify Engineer at least 3 days in advance of:
 - 1. Materials delivery.
 - 2. Start of stabilization activity.
- D. Seeding: Perform between March 15 and September 15.

1.6 MAINTENANCE

- A. Operations:
 - 1. Seeded Areas: Perform during maintenance period to include:
 - a. Watering: Keep seeded surface moist.
 - b. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.
 - c. Mulch: Replace wherever and whenever washed or blown away.
 - d. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
 - e. Reseed during next planting season if scheduled end of maintenance period falls after September 15.
 - f. Reseed entire area if satisfactory stand does not develop by July 1 of the following year.
 - g. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.
 - 2. Inspect, repair, and replace as necessary all erosion control measures during the time period from start of construction to completion of construction.
 - 3. Inspect a minimum of at least once every 7 days or after a 1/2-inch storm event in a 24-hour period.
 - 4. Furnish and install a rain gauge at the project site to monitor rainfall. At no time shall more than 1-foot depth of sediment be allowed to accumulate in any erosion control device.
- B. Sediment Removal:
 - 1. Remove sediment from erosion control devices and work into the grading plan at least once a week as required to maintain proper operation of devices. The cleaning operation shall not dispose of sediment offsite.
 - 2. Sediment shall be removed, and the controls upgraded or repaired as needed as soon as practicable, but not later than 2 days after the surrounding exposed ground has dried sufficiently to prevent further damage from equipment needed for repair operations.

3. In the event of continuous rainfall over a 24-hour period, or other circumstances that preclude equipment operation in the area, hand carry and install additional sediment controls as approved by the Engineer.

PART 2 - PRODUCTS

2.1 FERTILIZER

- A. Fertilizer shall not be used unless specifically approved by the Owner and a Natural Resource Specialist.

2.2 SEED

- A. Comply with Section 32 91 13 of the Specifications or submit temporary seeding mixture promoting native grass to be approved by Owner and Natural Resource Specialist.

2.3 MULCH

- A. Wood Cellulose Fiber Mulch:
 1. Specially processed wood fiber containing no growth or germination inhibiting factors.
 2. Dyed a suitable color to facilitate inspection of material placement.
 3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form a homogenous slurry.
 4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.
- B. Straw:
 1. Clean salt hay or threshed straw of oats, wheat, barley, or rye, free from seed of noxious weeds. Suitable for spreading with mulch blower equipment.
 2. Average Stalk Length: 6 inches.
 3. Seasoned before baling or loading.

2.4 REINFORCED PLASTIC COVERING

- A. Co-extruded, copolymer laminate reinforced with a nonwoven grid of high strength nylon cord submersed in a permanently flexible adhesive media allowing for equal tear resistance in all directions.
- B. Black in color and ultraviolet stabilized.
- C. Physical Requirement (Minimum Average Roll Values):
 1. Tear Strength: 130 pounds.
 2. Elongation: 620 percent.
 3. Minimum Thickness: 6 mil.
- D. Manufacturers:
 1. Reef Industries, Inc., Houston, TX.
 2. Griffolyn Co., Houston, TX.
 3. Engineer approved equal

2.5 SILT FENCE

- A. Support Posts: As recommended by manufacturer of geotextile.

- B. Fasteners: Heavy-duty wire staples at least 1-inch long, tie wires, or hog rings, as recommended by manufacturer of geotextile.
- C. Filter Fabric: Polyester, polypropylene, or nylon filaments, woven into a uniform pattern, distinct and measurable openings.
 - 1. Filaments: Resistant to damage from exposure to ultraviolet rays and heat.
 - 2. Material Edges: Finish so that, filaments retain their relative positions under stress.
- D. In accordance with requirements of Table No. 1:

Table No. 1 – Filter Fabric		
Physical Property	Required Value	Test Method
Weight, pz/sq yd, min.	4	ASTM D3776
Equivalent Opening Size, max.	50-70	U.S. Standard Sieve
Grab Tensile Strength, lb, min. ARV	160	ASTM D4632
Elongation, % max.	25	ASTM D1682
Mullen Burst Strength, psi, min. ARV	200	ASTM D3786
Ultraviolet Radiation Resistance, % Strength Retention	70	ASTM D4355
Flow Rate, gpm/sf, min. ARV	30 to 50	ASTM D4491

- E. Manufacturers:
 - 1. Polyfelt, Evergreen, AL.
 - 2. Dupont Co., Wilmington, DE.
 - 3. Mirafi, Inc., Charlotte, NC.
 - 4. Engineer approved equal

2.6 STRAW BALES

- A. Machine baled clean salt hay or straw of oats, wheat, barley, or rye, free from seed of noxious weeds, using standard baling wire or string.

2.7 POSTS FOR STRAW BALES

- A. 2-inch by 2-inch untreated wood or commercially manufactured metal.

2.8 DUST CONTROLLER

- A. Nontoxic materials that do not have an adverse effect on soil structure or establishment and growth of vegetation.

PART 3 - EXECUTION

3.1 GENERAL

- A. Erosion control measures are required during all construction and site disturbance activity and shall remain until permanent site ground covers are in place.
- B. The implementation of the erosion control plan and the construction maintenance, replacement and upgrading the erosion control devices are the responsibility of the Contractor until all construction is completed and landscaping established and approved. During the construction period, the erosion control devices shall be upgraded for unexpected storm events and to ensure that sediment and sediment laden water do not leave the site.
- C. Maintain existing buffer zones adjacent to project limits. Keep all construction equipment, debris and soils out of the natural buffer zone.

3.2 GRAVEL CONSTRUCTION ENTRANCES

- A. Provide a graveled construction access at each access point between the site and any public or private road or other paved surface.
- B. Place subgrade geotextile, as specified, on the ground prior to erosion control rock placement.
- C. Place erosion control rock over the geotextile to a minimum thickness of 8 inches.
- D. Minimum dimensions for construction entrances are 50-foot in length by 16-foot width.
- E. Contractor shall provide a minimum of 4 inches of erosion control rock for each entrance 3 times during the project at times directed by the Engineer to maintain proper function. More frequent applications of rock may be required, and if so, shall be considered as incidental work.

3.3 SOIL PREPARATION

- A. Before start of hydroseeding, and after surface has been shaped and graded, and lightly compacted to uniform grade, scarify soil surface to minimum depth of 1 inch.

3.4 SEEDING

- A. Prepare 1-inch depth seed bed; obtain Engineer's acceptance prior to proceeding.
- B. Apply by hydroseeding method on moist soil, but only after free surface water has drained away. Prevent drift and displacement of mixture into other areas.
- C. Summer Application:
 - 1. Prepare and apply slurry as recommended by supplier.
 - 2. Irrigation: 1-inch per week to seeded areas.

3.5 MULCHING

- A. Apply uniformly on disturbed areas that will remain undisturbed for 7 days or more, as requested by Engineer, and on all seeded areas.

- B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.
 - 1. Straw: Apply by hand or mechanical means to minimum depth of 2 inches.
 - 2. Wood Cellulose Fiber: 1,000 to 1,500 pounds per acre.

3.6 REINFORCED PLASTIC COVERING

- A. Place on areas where hydroseeding and erosion control matting have not controlled erosion and over all temporary stockpiles.
- B. Install in single thickness, strips parallel to direction of drainage. Anchor plastic in 6-inch by 6-inch trench backfilled with compacted native material.
- C. Maintain tightly in place by using sandbags on ropes with a maximum 10-foot grid spacing in all directions.
- D. Tape or weight down full length and overlap seams at least 12 inches.
- E. Remove at final acceptance unless notified otherwise by Engineer.

3.7 SILT FENCE

- A. Install prior to starting earth disturbing activities upslope of fence.
- B. One-piece filter fabric or continuously sewn to make one-piece filter fabric for full height of the fence, including portion buried in the toe trench.
- C. When joints are necessary, splice filter fabric together only at a support post, with a minimum 6-inch overlap, and securely fasten both ends to support post.
- D. Filter fabric shall not extend more than 24 inches above the ground surface. Securely fasten to upslope side of each support post using ties. Filter fabric shall not be stapled to existing trees.
- E. Fasten wire mesh material support fence securely to upslope side of post fasteners. Extend wire into the trench a minimum of 4 inches, and not more than 36 inches above the ground surface.
- F. Take precaution not to puncture filter fabric during installation. Repair or replace damaged area.
- G. Remove silt fence after upslope area has been permanently stabilized. Immediately dress sediment deposits remaining after the silt fence has been removed to conform to existing grade. Prepare and seed graded area.

3.8 TEMPORARY SOIL STOCKPILES

- A. Cover with reinforced plastic covering, as directed in Article REINFORCED PLASTIC COVERING.
- B. Protect perimeter of stockpile from erosion with ditches.

3.9 STRAW BALES

- A. Embed minimum of 4 inches in flat-bottomed trench. Place across swales or ditches to reduce velocities of concentrated flows. Space bales a minimum of 100-foot spacing.

- B. Place with ends tightly abutting or overlapped. Corner abutment is not acceptable.
- C. Install so that bale bindings are oriented around the sides and not over the top and bottom of the bale.
- D. Use two posts for each bale. Drive posts through the bale until top of post is flush with top of bale.
- E. Wedge loose straws in any gaps between bales.

3.10 DUST CONTROL

- A. Apply appropriate dust control measures on a continuous basis until permanent stabilization measures are in place.
- B. Apply on construction routes and other disturbed areas subject to surface dust movement and where off-site damage may occur if dust is not controlled.
- C. Avoid creating erosion when using water as a dust controller.

3.11 CLEAN-UP

- A. Sediment trapped in erosion control devices shall be regraded into the slopes on the site. Do not flush sediment-laden water into the drainage system.
- B. After site restoration is complete and when approved by the Engineer, all temporary erosion control measures shall be completely removed. Immediately shape and permanently stabilize areas affected by the removal process.
- C. Silt fence, straw bales, reinforced plastic covering, and any other erosion control devices shall be disposed off site to locations that are approved by federal, state, and local authorities.

END OF SECTION

SECTION 31 50 00 - EXCAVATION SUPPORT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work required to install and remove excavation support systems.
- B. Related sections:
 - 1. Section 31 23 23.13 – Fill and Backfill

1.2 SUBMITTALS

- A. Shop Drawings:
 - 1. Excavation support plan.
 - 2. Movement monitoring plan.
- B. Quality Control Submittals: Movement measurement and data and reduced results indicating movement trends.

1.3 QUALITY ASSURANCE

- A. Provide surveys to monitor movements of critical facilities.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

- A. Design, provide, and maintain shoring, sheeting, and bracing as necessary and where shown to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.
- B. Minimum areas for shoring, sheeting and bracing are shown on the Drawings. It will be the Contractor's responsibility to determine if areas will require excavation slope retention to protect existing structures and facilities from damage resulting from the Contractor's excavation or excavation methods.
- C. The Contractor will also be responsible for providing shoring, sheeting and bracing of excavations as needed for worker safety and as may be required by federal, state, and local regulations.

3.2 EXCAVATION SUPPORT PLAN

- A. Prepare excavation support plan addressing following topics:
 - 1. Details of shoring, bracing, sloping, or other provisions for worker protection of existing structures or facilities.
 - 2. Design assumptions and calculations.
 - 3. Methods and sequencing of installing excavation support.
 - 4. Proposed locations of stockpiled excavated material.
 - 5. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.

3.3 MOVEMENT MONITORING PLAN

- A. Prepare movement monitoring plan addressing following topics:
 - 1. Survey control.
 - 2. Locations of monitoring points (at least one every 50 feet).
 - 3. Plots of data trends.
 - 4. Interval between surveys (not to exceed 5 working days).
- B. Movement monitoring shall be done on every existing structure that is adjacent to the Contractor's excavations.
- C. Results of movement monitoring will be delivered for the Engineer at least once a week.

3.4 REMOVAL OF EXCAVATION SUPPORT

- A. Do not begin to remove excavation support until it can be removed without damage to existing facilities, completed Work, or adjacent property.
- B. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities. Maintain soil wall support as excavation is backfilled.
- C. Fill voids immediately with approved backfill compacted to density specified in Section 31 23 23.13, FILL AND BACKFILL.

END OF SECTION

DIVISION 32
EXTERIOR IMPROVEMENTS

SECTION 32 10 00 - CONCRETE SIDEWALKS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work and materials required to install concrete sidewalk.
- B. Related sections:
 - 1. Section 03 30 00 – Cast-In-Place Concrete.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Society for Testing and Materials (ASTM):
 - a. ASTM C94, Standard Specification for Ready Mixed Concrete.
 - b. ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - c. ASTM D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
 - 2. American Association of State Highway and Transportation Officials (AASHTO): T99.
 - 3. American Concrete Institute (ACI): ACI Guide for Measuring, Mixing, Transporting, and Placing Concrete.
 - 4. Standard Specification: The latest edition, including supplements of the Texas Department of Transportation Standard Specifications for Highway Construction.

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. Form Material: Information on metal forms, if used, including type, condition, surface finish, and intended function.
 - 2. Complete data on concrete mix, including aggregate gradations and admixtures in accordance with requirements of ASTM C94.
- B. Quality Control Submittals:
 - 1. Curing Compound: Manufacturer's Certificate of Compliance and application instructions.
 - 2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.

PART 2 - PRODUCTS

2.1 EXPANSION JOINT FILLER

- A. 1/2-inch thick, preformed asphalt-impregnated, expansion joint material meeting ASTM D994.

2.2 CONCRETE

- A. As specified in Section 03 30 00, Cast-In-Place Concrete.
- B. Maximum Aggregate Size: 1-1/2-inch.
- C. Slump: 2 to 4 inches.

2.3 CURING COMPOUND

- A. Liquid membrane-forming, clear or translucent, suitable for and meeting ASTM C309, Type 1.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Lumber Materials:
 - 1. 2-inch dressed dimension lumber, or metal of equal strength, straight, free from defects that would impair appearance or structural quality of completed sidewalk.
 - 2. 1-inch dressed lumber or plywood may be used where short-radius forms are required.
- B. Metals: Steel in new undamaged condition.
- C. Setting Forms:
 - 1. Construct forms to shape, lines, grades, and dimensions.
 - 2. Stake securely in place.
- D. Bracing:
 - 1. Brace forms to prevent change of shape or movement resulting from placement.
 - 2. Construct short-radius curved forms to exact radius.
- E. Tolerances:
 - 1. Do not vary tops of forms from gradeline more than 1/8-inch when checked with 10-foot straightedge.
 - 2. Do not vary alignment of straight sections more than 1/8-inch in 10 feet.

3.2 PLACING CONCRETE

- A. Prior to placing concrete, remove water from excavation and debris and foreign material from forms.
- B. Place concrete as soon as possible, and within 1-1/2 hours after adding cement to mix without segregation or loss of ingredients, and without splashing.
- C. Place, process, finish, and cure concrete in accordance with applicable requirements of ACI 304, and this section. Wherever requirements differ, the more stringent shall govern.
- D. To compact, vibrate until concrete becomes uniformly plastic.

3.3 SIDEWALK CONSTRUCTION

- A. Thickness:
 - 1. 4 inches in walk areas.
 - 2. 6 inches in driveway areas.
- B. Connection to Existing Sidewalk:
 - 1. Remove old concrete back to an existing contraction joint.
 - 2. Clean the surface.
 - 3. Apply a neat cement paste immediately prior to placing new sidewalk.
- C. Expansion Joints: Place at building corners and changes in sidewalk width around posts, poles, or other objects penetrating sidewalk. Install expansion joint filler at each joint.
- D. Contraction Joints:
 - 1. Provide transversely to walks at locations opposite contraction joints in curb.
 - 2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
 - 3. Construct straight and at right angles to surface of walk.

- E. Finish:
 - 1. Broom surface with fine-hair broom at right angles to length of walk and tool at edges, joints, and markings.
 - 2. Mark walks transversely at 5-foot intervals with jointing tool; finish edges with rounded steel edging tool.
 - 3. Apply curing compound to exposed surfaces upon completion of finishing.
 - 4. Protect sidewalk from damage and allow to cure for at least 7 days.

3.4 SLAB CONSTRUCTION ON GRADE

- A. Thickness: Four inches or as shown.
- B. Contraction Joints:
 - 1. As shown on Drawings.
 - 2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
 - 3. Construct straight and at right angles to surface of slab.
- C. Finish:
 - 1. Broom surface with fine-hair broom and tool of edges, joints, and markings.
 - 2. Apply curing compound to exposed surfaces upon completion of finishing.
 - 3. Protect sidewalk from damage and allow to cure for at least 7 days.

END OF SECTION

SECTION 32 11 00 - BASE COURSE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work and materials required to install base course.
- B. Related sections:
 - 1. Section 31 22 13 – Subgrade Preparation.

1.2 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):
 - a. T 89, Standard Method for Determining the Liquid Limit of Soils.
 - b. T 90, Determining the Plastic Limit and Plasticity Index of Soils.
 - c. T 96/ASTM C131, Standard Method for Resistance to Degradation of Small Size Course Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - d. T 99, Standard Methods of Test for the Moisture-Density Relations of Soils Using a 5.5-pound (2.5 kg) Rammer and a 12-inch (305 mm) Drop.
 - e. T 180, Standard Methods of Test for the Moisture-Density Relations of Soils Using a 10-pound (4.54 kg) Rammer and an 18-inch (457 mm) Drop.
 - f. T 191, Standard Method of Test for Density of Soil In-Place by the Sand-Cone Method.
 - g. T 238, Standard Method of Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

1.3 DEFINITIONS

- A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.
- B. Completed Lift: Compacted with uniform surface reasonably true to cross- section.
- C. Standard Specifications: The latest edition, including supplements, of the Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

1.4 SUBMITTALS

- A. Quality Control Submittals:
 - 1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 20 days prior to delivery of materials to project.
 - 2. Certified Results of In-Place Density Tests from independent testing agency.

PART 2 - PRODUCTS

2.1 BASE COURSE ROCK

- A. As specified for Type A, Grade 2 of Item 247 of the Standard Specifications.

2.2 SOURCE QUALITY CONTROL

- A. Contractor: tests necessary to locate acceptable source of materials meeting specified requirements.
- B. Final approval of aggregate material will be based on materials' test results on installed materials.
- C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 - EXECUTION

3.1 PREPARATION

- A. As specified in Section 31 22 13, Subgrade Preparation.
- B. Obtain Engineer's acceptance of subgrade before placement of base course rock.
- C. Do not place base materials in snow or on soft, muddy, or frozen subgrade.

3.2 EQUIPMENT

- A. In accordance with Section 3 of Item 247 of the Standard Specifications.
- B. Compaction Equipment: Adequate in design and number to provide compaction and obtain the specified density for each layer.

3.3 HAULING AND SPREADING

- A. Hauling Materials:
 - 1. Do not haul over surfacing in process of construction.
 - 2. Loads: Of uniform capacity.
 - 3. Measure capacity of truck to determine vehicle load and quantity.
 - 4. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.
- B. Spreading Materials:
 - 1. Distribute material to provide required density, depth, grade and dimensions with allowance for subsequent lifts.
 - 2. Produce even distribution of material upon roadway without segregation.
 - 3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.4 CONSTRUCTION OF COURSES

- A. General: Complete each lift in advance of laying succeeding lift to provide required results and adequate inspection.
- B. Base Course:
 - 1. Maximum Completed Lift Thickness: 6 inches.
 - 2. Completed Course Total Thickness: As shown.
 - 3. Spread lift on preceding course to required cross-section.
 - 4. Lightly blade and roll surface until thoroughly compacted.
 - 5. Add keystone to achieve compaction and as required when aggregate does not compact readily due to lack of fines or natural cementing properties, as follows:

- a. Use base 1/4-minus crushed aggregate material as keystone.
 - b. Spread evenly on top of crushed base course, using spreader boxes or chip spreaders.
 - c. Roll surface until keystone is worked into interstices of crushed base course without excessive displacement.
 - d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.
6. Blade or broom surface to maintain true line, grade, and cross-section.

3.5 ROLLING AND COMPACTION

- A. Blade or otherwise work existing surface as necessary to achieve a smooth and thoroughly compacted surface.
- B. Commence compaction of each layer of base after spreading operations and continue until density of 100 percent of maximum density has been achieved as determined by AASHTO T 99.
- C. Commence rolling at outer edges of surfacing and continue toward center; do not roll center of road first.
- D. Apply water as needed to obtain densities.
- E. Place and compact each lift to required density before succeeding lift is placed.
- F. Bind up preceding course before placing leveling course. Remove floating or loose stone from surface.
- G. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.
- H. Surface Defects: Remedy surface defects by loosening and rerolling entire area, including surrounding surface, until thoroughly compacted.
 - 1. Finished Surface: True to grade and crown before proceeding with surfacing.

3.6 SURFACE TOLERANCES

- A. Finished Surface of Base Course: Within plus or minus 0.04-foot of grade shown at any individual point.
- B. Overall Average: Within plus or minus 0.01-foot from crown and grade specified.

3.7 FIELD QUALITY CONTROL

- A. In-Place Density Tests:
 - 1. Construct base course so areas shall be ready for testing.
 - 2. Allow reasonable length of time for testing laboratory to perform tests and obtain results during normal working hours.
 - 3. Show proof that areas meet specified requirements before identifying density test locations.
 - 4. Perform a minimum of 2 tests on completed course per 200 cubic yards of material placed in accordance with T 191, or T 238 at locations acceptable to Engineer.
- B. Cleaning
 - 1. Remove excess material; clean stockpile areas of aggregate.

END OF SECTION

SECTION 32 31 13 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society for Testing and Materials (ASTM):
 - a. ASTM A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
 - b. ASTM A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
 - c. ASTM A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
 - d. ASTM A1018, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 - e. ASTM A824, Standard Specification for Metallic-Coated Steel Marcellled Tension Wire for Use with Chain Link Fence.
 - f. ASTM B6, Standard Specification for Zinc.
 - g. ASTM C94, Standard Specification for Ready-Mixed Concrete.
 - h. ASTM C143, Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - i. ASTM C387, Standard Specifications for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar.
 - j. ASTM F552, Standard Terminology Relating to Chain Link Fencing.
 - k. ASTM F567, Standard Practice for Installation of Chain-Link Fence.
 - l. ASTM F626, Standard Specification for Fence Fittings.
 - m. ASTM F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
 - n. ASTM F900, Standard Specification for Industrial and Commercial Swing Gates.
 - o. ASTM F1043, Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework.
 - p. ASTM F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
 - q. ASTM F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
 - r. ASTM F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
 2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: National Electrical Safety Code.
 3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

1.2 DEFINITIONS

- A. Terms as defined in ASTM.

1.3 SUBMITTALS

- A. Shop Drawings:
1. Detailed information and specifications for materials, finishes, and dimensions.
 2. Card access system serial communication interface card code message format.
- B. Samples: Approximately 6 inches square, or 6 inches long of posts, rails, braces, fabric, wire, ties, and fittings.

- C. Quality Control Submittals:
 - 1. Manufacturer's recommended installation instructions.
 - 2. Evidence of Supplier and installer qualifications.

1.4 SCHEDULING AND SEQUENCING

- A. Complete necessary site preparation and grading before installing chain link fence and gates.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Match style, finish, and color of each fence component with that of other fence components.

2.2 CHAIN LINK FENCE FABRIC

- A. Galvanized fabric conforming to ASTM, Class 1; galvanized after weaving.
- B. Height: 72 inches, unless otherwise shown.
- C. Wire Gauge: No. 9, barewire.
- D. Pattern: 2-inch diamond-mesh.
- E. Diamond Count: Manufacturer's standard and consistent for fabric furnished of same height.
- F. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.
- G. Wires of Twisted Selvages:
 - 1. Twisted in a closed helix three full turns.
 - 2. Cut at an angle to provide sharp barbs that extend minimum 1/4-inch beyond twist.

2.3 POSTS

- A. General:
 - 1. Strength and Stiffness Requirements: ASTM F1043, Light Industrial Fence, except as modified in this section.
 - 2. Steel Pipe: ASTM F1083.
 - 3. Roll-Formed Steel Shapes: from ASTM A1018, Grade 45, Steel.
 - 4. Lengths: Manufacturer's standard with allowance for minimum embedment below finished grade of 22 inches plus 3 inches for each 1 foot of fence height greater than 4 feet.
 - 5. Protective Coatings:
 - a. Zinc Coating: ASTM F1043, Type A external and internal coating.
- B. Line Posts:
 - 1. Steel Pipe:
 - a. Outside Diameter: 2.375-inch.
 - b. Weight: 3.65 pounds per foot.
- C. End, Corner, Angle, and Pull Posts:
 - 1. Steel Pipe:
 - a. Outside Diameter: 2.875-inch.
 - b. Weight: 5.79 pounds per foot.

- D. Posts for Swing Gates:
 - 1. ASTM F900.
 - a. Outside Dimensions: 4-inch diameter.
 - b. Weight: 6.56 pounds per foot.

2.4 TOP RAILS AND BRACE RAILS

- 1. Galvanized steel pipe.
- 2. Protective Coatings: As specified for posts.
- 3. Strength and Stiffness Requirements: ASTM F1043, Top Rail, Heavy or Light Industrial Fence.
- 4. Steel Pipe:
 - a. ASTM F1083.
 - b. Outside Diameter: 1.66-inch.
 - c. Weight: 2.27 pounds per foot.

2.5 FENCE FITTINGS

- A. General: In conformance with ASTM F626, except as modified by this article.
- B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.
- C. Tension and Brace Bands: No exceptions to ASTM.
- D. Tension Bars:
 - 1. One-piece, no exceptions to ASTM F626.
 - 2. Equal in length to full height of fabric.
- E. Truss Rod Assembly: 3/8-inch diameter.
- F. Barb Arms: 45-degree arms for supporting three strands of barbed wire.

2.6 TENSION WIRE

- A. Zinc-coated steel marcelled tension wire conforming to ASTM A824, Type II, Class 2.

2.7 BARBED WIRE

- A. Zinc-Coated Barbed Wire: ASTM A121, Chain Link Fence Grade:
 - 1. Line Wire: Two strands of No. 12-112 gauge.
 - 2. Barbs:
 - a. Number of Points: Four.
 - b. Length: 3/8-inch minimum.
 - c. Shape: Round.
 - d. Diameter: No. 14-gauge.
 - e. Spacing: 5 inches.

2.8 GATES

- A. General:
 - 1. Gate Operation: Opened and closed easily by one person.
 - 2. Welded Steel Joints: Paint with zinc-based paint.
 - 3. Chain Link Fabric: Attached securely to gate frame at intervals not exceeding 15 inches.
- B. Swing Gates: ASTM F900.

1. Hinges:
 - a. Furnished with large bearing surfaces for clamping in position.
 - b. Designed to swing either 180 degrees outward, 180 degrees inward, or 90 degrees in or out, as shown, and not twist or turn under action of gate.
2. Latches: Plunger bar arranged to engage stop, except single gates of openings less than 10 feet wide may each have forked latch.
3. Gate Stops: Mushroom type or flush plate with anchors, suitable for setting in concrete.
4. Locking Device and Padlock Eyes: Integral part of latch, requiring one padlock for locking both gate leaves of double gates.
5. Hold-Open Keepers: Designed to automatically engage gate leaf and hold it in open position until manually released.

2.9 CONCRETE

- A. Provide as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

2.10 REPAIR AND SALVAGE OF EXISTING FENCE

- A. Non-Salvageable or Non-Reusable Parts:

1. Fence posts.
2. Gate posts.
3. End, corner angle, and pull posts.
4. Tension and brace bands.
5. Tension wire.

- B. Salvageable or Reusable Items:

1. Fence fabric.
2. Post caps.
3. Top rails and brace rails.
4. Truss rod assemblies.
5. Barb arms.
6. Barbwire.

- C. All items noted as salvageable shall not be bent, twisted, dented, or damaged in any way. Any such items will not be considered for reuse.

- D. All items not considered for salvage or reuse shall be disposed of offsite at the Contractor's expense. See Section 02 41 00, DEMOLITION.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install chain link fences and gates in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer's recommendations, as approved by Engineer. Erect fencing in straight lines between angle points.
- B. Provide all necessary hardware for a complete fence and gate installation.

3.2 PREPARATION

- A. Establish locations of fence lines, gates, and terminal posts.

3.3 POST SETTING

- A. Driven posts are not acceptable.
- B. Post Hole Depth:
 - 1. Minimum 3 feet below finished grade.
 - 2. 2 inches deeper than post embedment depth below finish grade.
- C. Backfill post holes with concrete to 2 inches above finished grade.
- D. Before concrete sets, crown and finish top of concrete to readily shed water.

3.4 BRACING

- A. Brace gate and corner posts diagonally to adjacent line posts to ensure stability.

3.5 TOP RAILS

- A. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

3.6 CHAIN LINK FABRIC

- A. Do not install fabric until concrete has cured minimum 7 days.
- B. Install fabric with twisted and barbed selvage at top.

3.7 BARBED WIRE

- A. Install three strands of barbed wire on brackets, tighten, and secure at each bracket.

3.8 GATES

- A. Hang gates and adjust hardware so gates operate satisfactorily from open or closed position.
- B. Set gate stops in concrete to engage center drop rod or plunger bar.

3.9 FIELD QUALITY CONTROL

- A. Gate Tests: Prior to acceptance of installed gates and gate operator systems, demonstrate proper operation of gates under each possible open and close condition specified.

3.10 REUSE OF EXISTING FENCE MATERIAL

- A. Existing fence material shall be installed on new posts using new tension bars, brace bands, and tension wire.
- B. Existing fence fabric shall not be spliced to new fence fabric at mid-length between posts where the existing fence fabric ends. A pull post shall be installed with new brace bands, tension bands, and tension wire. Provide a knuckled selvage at the cut portion of the fence as shown on the Drawings.

END OF SECTION

SECTION 32 91 19 - SEEDING, FERTILIZING, AND MULCHING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Sodding.
 - 2. Fertilizer.
 - 3. Mulch.
 - 4. Seed.
 - 5. Preparation.
 - 6. Maintenance.
- B. Related Sections:
 - 1. Section 31 23 16 – Excavation
 - 2. Section 31 23 23.13 – Fill and Backfill
- C. Alternate Methods and Products:
 - 1. Alternate methods from those specified will be considered for use, provided that in the Engineer's opinion the end product will be equal to or exceed that which would result from the specified methods and products.

1.2 DEFINITIONS

- A. Weeds:
 - 1. Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wold Garlic, Perennial Sorrel, and Brome Grass.

1.3 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.

1.4 QUALITY ASSURANCE

- A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.5 MAINTENANCE DATA

- A. Submit maintenance data for continuing Owner maintenance.
- B. Include maintenance instruction, cutting method, maximum grass height, types, application frequency, and recommended coverage of fertilizer.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.
- B. Deliver fertilizer in water proof bags showing weight, chemical analysis, and name of manufacturer.

PART 2 - PRODUCTS

2.1 AGRICULTURAL LIMESTONE

- A. Shall be agricultural limestone with not less than 90 percent passing the No. 4 sieve and containing not less than 40 percent calcium carbonate equivalent. Lime shall be applied at the rate recommended by soil test.

2.2 FERTILIZER

- A. No fertilizer shall be used unless approved by Natural Resource Specialist and Owner

2.3 MULCH

- A. Shall be vegetative mulch consisting of cereal straw from stalks of oats, rye, wheat or barley. Straw shall be free of prohibited weed seeds as stated in State Seed Law and shall be relatively free of all other noxious and undesirable seeds. Straw shall be clean and bright, relatively free of foreign material and be dry enough to be spread properly.

2.4 SEED

- A. Seed shall be a mixture as follows, or approved by a Natural Resource Specialist and Owner for use at Enchanted Rock State Natural Area:

<u>Seed Type</u>	<u>% Mix (By Wt.)</u>
little bluestem	40
sideoats grama	25
green sprangletop	25
sand dropseed	10

Variation in the above mix to suit local conditions or time of year may be required.

- B. Seed shall be labeled in accordance with USDA regulations. Care shall be taken during transportation to avoid segregation of seed mixtures.
- C. Seed shall be sown at a rate of 5.5 pounds of seed mix per acre or as recommended by supplier and approved by Natural Resource Specialist and Owner.

PART 3 - EXECUTION

3.1 GENERAL

- A. The application of fertilizer, seed, and mulch shall follow each other in successive sequence as closely as possible. Seeding shall be accomplished in the first of the following two periods after completion of earthwork.

February 15 to May 1st
September 1st to October 1st

- B. Seeding outside the specified seeding periods may be permitted at the Engineer's option, provided the Contractor is willing to make appropriate modifications to his seeding operations, and will guarantee the crop.

3.2 INSPECTION

- A. Contractor must request that Engineer inspect site grading, clean-up and surface preparation to determine if site is ready for the seeding, fertilizing and mulching operations.
- B. Upon Engineer's approval operations may begin.

3.3 SURFACE PREPARATION

- A. Immediately in advance of fertilizing, the surface to be seeded shall be repaired, if necessary, to eliminate all damage from erosion or construction operations. The surface shall then be loosened and thoroughly pulverized by discing, harrowing and raking or other approved methods, to such an extent that it is free from sod, stones, clods, or roots. All growth of vegetation that will seriously interfere with planting operations shall be removed and disposed of as directed. The final surface shall be smooth and uniform, and left in such a condition as to prevent formation of low places and pockets.

3.4 SEEDING METHODS

- A. General methods:
 - 1. The Contractor shall employ a satisfactory method of sowing by use of either approved mechanical hand seeders or mechanical power-driven drills. When delays in operation carry the work beyond the specified planting seasons, or when conditions are such that by reason of drought, high winds, excessive moisture, or other factors, satisfactory results are not likely to be obtained, seeding shall stop. It will be resumed only where the desired results are probable or when approved alternate procedures have been adopted.
- B. Broadcast seeding:
 - 1. When broadcast seeding is utilized, the seed shall be uniformly broadcast by mechanical hand seeder, in two directions at right-angles to each other and at 1/2 of the specified rate per acre in each direction. After the seed is broadcast it shall be covered by an approved method to a depth of 1/3 inch to 3/4 inch. Broadcast seeding shall not be done in windy weather.
- C. Drill seeding:
 - 1. When drilling is utilized, it shall be done with approved equipment best suited to perform the work under prevailing conditions. The seed shall be uniformly drilled to a depth of one-third (1/3) inch to three-fourths (3/4) inch at the rate per acre specified. Drill seeding may be required in windy weather.
- D. Prior to start of seeding, the Contractor shall demonstrate that the application of seed is being made at the specified rate. A final check of the total quantity of seed used shall be made against the area seeded. If the check shows that the Contractor has not applied seed at the specified rate, he shall uniformly distribute seed at a rate calculated to meet the shortage.
- E. The Contractor shall maintain the seeded areas until all seeding and mulching is complete and the work accepted by the Engineer. Areas damaged from the Contractor's own operations shall be repaired at his expense. After acceptance of the work the Contractor will not be held responsible for erosion due to weather, or conditions not due to the Contractor's own operations or negligence. The Contractor is not required to guarantee a crop, if seeding is done during the specified seeding periods.

3.5 MULCHING

- A. Immediately after seeding, the Contractor shall apply vegetative mulch at a rate between 1-1/2 and 2-1/2 tons per acre to all seeded areas. Quantity of mulch shall be adjusted within the above limits, as directed by the Engineer, to the particular area or slope being mulched. Total application of mulch for the project shall average approximately 2 tons per acre. Mulch shall be applied by mechanical mulch spreaders equipped to eject by means of a constant air stream controlled quantities of the vegetative mulch.
- B. Mulch shall be embedded by a disc type roller having flat serrated discs spaced not more than 10 inches apart, with cleaning scrapers for each disc.
- C. Where indicated, or in areas of the project where soil conditions are not suitable for satisfactory crimping, asphalt emulsion shall be applied with the mulching operation. The normal rate of application shall be 100 gallons per ton of straw; however, this rate may be varied as directed by the Engineer to suit the particular area or slope conditions.
- D. All mulch shall be distributed evenly over the areas to be mulched within 24 hours after the seeding operation. Following the mulching operation, suitable precautions shall be taken to prohibit traffic over mulched areas. Displaced mulch shall be replaced immediately, including repair of the underlying seed bed, if damaged as well.

3.6 MAINTENANCE

- A. The Contractor shall maintain all seeded areas until the grass is properly established (not less than 90 days) until satisfactory development. Maintenance shall be continued until final acceptance of the work.
- B. Maintenance of seeded areas shall include protecting, watering, mowing, fertilizing, and such other work as may be necessary to establish a permanent lawn. The Contractor shall reseed those seeded areas in which a satisfactory growth is not obtained, and shall refill any areas which become eroded prior to final acceptance of the work.
- C. Paved areas shall be kept clean while maintenance operations are in progress.

3.7 REPLACEMENT

- A. The Contractor shall replace all trees, shrubs, and flowers damaged by construction activities in the areas designated on the construction plans. The replacement trees and shrubs shall be equal in size to the damaged or removed specimen.

END OF SECTION

DIVISION 33
UTILITIES

SECTION 33 11 11 – PIPING LEAKAGE TESTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Work, materials, and procedures required to test piping installed as part of this project.
 - 2. Work, materials, and procedures required to test piping within the existing water distribution system downstream of the booster pump station to be installed with this project.
- B. Related sections:
 - 1. Section 40 23 39 – Process Piping General.
- C. See Section 40 23 39, PROCESS PIPING GENERAL, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

1.2 SUBMITTALS

- A. Submittals shall be made as required in the Special Conditions. The following specific information shall be provided:
 - 1. Quality Control Submittals:
 - a. Testing Plan: Submit at least 30 days prior to testing and include at least the information that follows.
 - 1) Testing dates.
 - 2) Piping systems and sections(s) to be tested.
 - 3) Test type.
 - 4) Method of isolation.
 - 5) Calculation of maximum allowable leakage for piping sections(s) to be tested.
 - 6) Shutdown plan and schedule for taking existing portions of water distribution system offline.
 - b. Certifications of Calibration: Testing equipment.
 - c. Certified Test Report.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Contractor shall present written plan for proposed method and schedule to test existing water distribution system mains to be approved by Engineer. Contractor shall at minimum, isolate and separately test piping segments between existing valves. Plan shall include proposed test segments and pressures, means of isolation, method of testing appurtenance installation, anticipated times and plan for locating leaks if determined to exist. Schedule for testing and necessary shutdown shall be coordinated with owner's schedule prior to submittal.
- B. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.
- C. Pressure Piping:

1. Install temporary thrust blocking or other restraint (i.e. solvent welded joints) as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
4. New Piping connected to Existing Piping:
 - a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.
 - b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Engineer.
5. Items that do not require testing include: Equipment seal drains, tank overflows to atmospheric vented drains, and tank atmospheric vents.
6. Test Pressure:
 - a. New lines: As indicated on the Piping Schedule.
 - b. Existing Distribution Lines: Maximum working pressure of segment being tested plus 10 psi.

D. Test section may be filled with water and allowed to stand under low pressure prior to testing.

3.2 HYDROSTATIC TEST FOR NEW PRESSURE PIPING

A. Test piping as indicated in pipe schedule.

B. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.

C. Exposed Piping:

1. Perform testing on installed piping prior to application of insulation.
2. Maximum Filling Velocity: 0.25 feet per second, applied over full area of pipe.
3. Vent piping during filling: Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
4. Maintain hydrostatic test pressure continuously for 60 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
5. Examine joints and connections for leakage.
6. Correct visible leakage and retest as specified.
7. Empty pipe of water prior to final cleaning.

D. Buried Piping:

1. Test after backfilling has been completed.
2. Expel air from piping system during filling.
3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
6. Maximum Allowable Leakage:

$$Q = \frac{L D \sqrt{P}}{148,000}$$

Where:

Q = testing allowance (makeup water) (gph)

L = length of pipe tested (ft)

D = nominal diameter of the pipe (in.)

P = average test pressure during the hydrostatic test (psi [gauge])

7. Correct leakage greater than allowable, and retest as specified.

3.3 PNEUMATIC TEST FOR PRESSURE PIPING

- A. Test piping as indicated in pipe schedule.
- B. Do not perform on:
 1. PVC or CPVC pipe.
 2. Piping larger than 18 inches.
 3. Buried and other non-exposed piping.
- C. Fluid: Oil-free, dry air.
- D. Procedure:
 1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections, examine for leakage.
 2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
 3. Gradually increase pressure in system to half of specified test pressure. Thereafter increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
 4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
 5. Correct visible leakage and retest as specified.
- E. Allowable Leakage: Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.
- F. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

3.4 TESTING AND REPAIRS FOR EXISTING DISTRIBUTION PIPING

- A. Testing
 1. Contractor shall pressure test existing park water piping systems to locate leaks or failures within the system. Piping to be tested includes: raw water piping from existing wells to the existing storage tank, existing distribution piping 1" and larger from the meter vault at the pump station site through the distribution system.
 2. Follow approved testing schedule required in this Section.
 3. Isolate pipe segments and install necessary appurtenances for testing as approved in plan.
 4. Test in accordance with 3.2.D of this section at pressure as described in 3.1.C and as approved in plan.
 5. Alert Engineer and Owner immediately of failing test results.
- B. Leak Detection
 1. Where failing pressure tests indicate existing system leaks, Contractor shall use acoustical or alternate non-evasive leak detection equipment, to locate suspected leak areas.

2. Upon non-evasive location of potential leaks, Contractor shall spot excavate to confirm leaks and document and photograph location, extent, and type of leak and report to owner as soon as possible.
3. During testing and investigation of the existing water system, Contractor shall coordinate with Owner to ensure Public safety and Park operations.

C. Repair Method for Existing Water System

1. As directed by Owner and Engineer, isolate, remove and replace existing distribution system piping with new Schedule 80 PVC piping as referenced in Section 40 23 39.43.
2. Replace at minimum, 20 foot joints of pipe.
3. Install one new gate valve of same size as line at each repair as specified in Section 40 23 43. Valve shall be located to minimize lengths of unvalved piping.
4. Disinfect and retest repairs pipe sections.

3.5

3.5 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.
5. Remarks, including:
 - a. Leaks (type, location).
 - b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 33 11 17 – REHABILITATION OF EXISTING WELLS

PART 1 - GENERAL

1.1 SUMMARY

- A. The work covered by Specifications consists of furnishing all labor, equipment, machinery, and materials and performing all operations in connection with the rehabilitation of public water supply wells for Texas Parks and Wildlife Department. It is the intent of these Specifications that water service be uninterrupted as much as possible. Wherever the term “Engineer” is used in this Section, it shall be construed to mean “Collier Consulting, Inc.”, or its designated representatives. Wherever the term “Owner” is used in the Specifications, it shall be construed to mean “Texas Parks and Wildlife Department”, or its designated representatives.

1.2 REHABILITATION SITE

- A. During rehabilitation of the wells, the Contractor shall keep the site free and clear of all rubbish and debris and shall clean-up the site promptly when notified to do so by the Engineer or Owner. The Contractor shall, at his own expense, maintain streets free from dust, mud, excess earth, or debris which constitutes a nuisance or danger to the public using the thoroughfare or the occupants of the adjacent properties. Care shall be taken to prevent spillage on streets over which hauling is done. Any such spillage or debris due to construction operations shall be immediately removed.

1.3 TRADE NAMES

- A. Except as specified otherwise, wherever in the Specifications an article or class of material is designated by a trade name or by the name or catalog number of any maker, patentee, manufacturer, or dealer, such designations shall be taken as intending to mean and specify the articles described or another equal thereto in quality, finish, and serviceability for the purpose intended, as may be determined and judged by the Engineer in his sole discretion. Where materials or equipment are specified by a trade or brand name, it is not the intention of the Owner or Engineer to discriminate against an equal product of another manufacturer, but rather to set a definite standard of quality for performance.

1.4 SAFETY

- A. All work shall comply with the rules set out by the Occupational Safety and Health Act. A minimum of one competent person who is not working in the excavation shall monitor excavations exceeding four feet in depth. The person shall be trained to recognize dangerous conditions, proper use of trench protection, CPR, and First Aid in accordance with 29 CFR 1926, Subpart P. All excavations over five feet deep shall be shored, shielded, or sloped in accordance with 29 CFR, Subpart P.
- B. Machinery guards and safety devices shall be present and functional on all equipment. Workers present at the work site shall at a minimum wear steel toe boots, hardhat, and gloves; eye protection shall be worn as needed to protect worker safety in accordance to 29 CFR 1926 Subpart P.
- C. 6-foot temporary fencing shall always be used during construction to prevent unauthorized entry to the work site. The fencing shall be of sufficient design to provide reasonable security to the site and protection to the general public. Fencing shall not be necessary during trenching and pipe laying unless any open trench or bore pit is to be left unattended by Contractor.

1.5 CONTAMINATION PRECAUTIONS

- A. The Contractor shall avoid contamination of the project area. No oil, rubbish, or other waste material shall be dumped on the ground. All petroleum fuels and lubricants are to be stored and handled in accordance with state and local regulations. The Contractor shall be responsible for remediation or restoration that may result from construction activities.

1.6 DISPOSAL OF MATERIAL

- A. Unless otherwise specifically authorized, all objectionable material is the Contractor's property and must be removed from the project area. Material can include but is not limited to spoils, acidized material, bailed fill, rocks, brush, trees, debris, etc.

PART 2 - REHABILITATION OF EXISTING WELLS

2.1 ESTABLISH BASELINE PRODUCTION

- A. Initial Production Testing – Constant Rate Test
 1. Production testing shall not proceed until static water levels are stable as indicated by two identical consecutive readings 30 minutes apart. Should stable conditions not occur, testing may commence after 4 hours of non-stable readings. Gauges used in the collection of water level data shall be accurate to 0.1 psi and not be over-pressured during the test. This may necessitate using different gauges during different portions of the test.
 2. Water level measurement may be made by an approved pressure transducer set to record pressure at an interval no greater than one (1) minute. In no case shall water levels be measured with an airline. If measurements are taken by hand using an electric line, they shall conform to the following schedule for each step:

Prior to Test -	at 30-minute intervals for 4 hours unless stable
First 10 minutes	at 1, 1.5, 2, 3, 4, 6, 8, and 10 minutes
From 10 - 120 minutes -	at 15, 20, 25, 30, 40,60, 80, and 100 and 120 minutes
After 120 minutes -	at 1-hour intervals until completion of pumping or next step
After pumping ceases -	repeat the above schedule through 4 hours
 3. Production testing shall proceed for a minimum of 2 hours. Production testing may be shortened due to site specific conditions. Shortening of test must be approved by Engineer.
 4. The test rate shall be typical of normal production. The water flow rate measurement shall be made through a water meter with both cumulative gallons and instantaneous gallons per minute. The meter shall be furnished by the Contractor and acceptable to the Engineer. The flow rate shall be recorded together with the time of the measurement periodically through the test, and the discharge shall be adjusted to maintain a constant rate. The test shall be continuous.
 5. The production test shall measure specific capacity.
 6. Contractor shall provide Engineer with water level data and records of discharge.
- B. Extraction of Pumping Equipment
 1. Contractor shall extract and inspect pumping equipment from well for any defects. Defects can include but are not limited to chaffed wire, burnt wire, excessive corrosion/rust on column pipe, leaking check valves, etc. The Contractor shall notify Engineer of any defects and Owner may direct Contractor to replace defective equipment for additional cost.
 2. Contractor shall keep all pumping equipment off the ground using sawhorses for the column pipe and a cable drum for the power cable. All pumping equipment shall be secured when Contractor is not onsite.
- C. Initial Downhole Video Survey

1. A downhole video survey shall be performed to visually inspect the integrity of the well, condition of surface casing, to identify fractures or fracture zones intersecting the open hole well bore, the presence and type of scale, the presence of biofouling, and the amount of fill.
2. A downhole video shall be performed with a full color camera with capabilities of a downhole view, side view with 360-degree rotation and digital depth counter accurate to +- 1%. Downhole video shall be recorded either on a DVD or thumb drive for record.
3. The downhole video shall be performed to the satisfaction of the Engineer. It is recommended the survey perform a full 360-degree rotation every one (1) foot depth increment.
4. Contractor shall provide Engineer with a copy of the video upon completion.
5. After review, Engineer, in consultation with Owner, may direct Contractor to bail the well, conduct only mechanical brushing, to proceed with full rehabilitation or to cease rehabilitation altogether.

D. Bail Fill (if applicable)

1. Contractor shall remove any fill noted in the well from the downhole well video survey. The contractor shall utilize a piston style bailer. Fill shall be removed to the satisfaction of the Engineer.

E. Mechanical Cleaning (if applicable)

1. Contractor shall use an adequately sized well brush for the production section to mechanically clean the producing zone and casing. The Contractor shall brush the producing section for a minimum of two (2) hours. Repeat bailing.

F. Acidizing (if applicable)

1. After brushing and bailing additional fill from well, fill a tank near the well head with water to mix chemistry. Set tremie assembly for placement of chemistry.
2. In this surface tank, start a pump recirculating water. Slowly pour granular acid into the intake for mixing. Slowly pour Catalyst into the intake for mixing. Displace the chemistry at 10' increments from the bottom of well.
3. Start development immediately using a surge block but operate in the production area only. A block speed of 2-3' second is important to gain velocity into the formation. Start at the bottom of the formation and work upwards in 3', 5', or 10' increments, spending 15 minutes per increment. Monitor pH/color with a bailer. Repeat procedure for 2.5-3 hours.
4. When/if pH rises above 3.0, adjust pH by adding granular acid. Recommend having enough granular acid onsite for 2 adjustments. Set tremie line to middle of the producing formation and pump entire chemistry. Continue to surge, monitor pH/color every 3-4 hours, and adjust accordingly. Before leaving site in PM, always check pH and adjust if above 2.5. In AM, always surge for 20- 30 min before checking pH to mix chemicals in well. If lower than 3, continue to surge and monitor in two hours. Adjust accordingly.
5. Iron, coloration of chemistry will initially be dark brown (iron in suspension) and will turn yellow and clear as iron goes into solution. Manganese, expect coloration to initially be black and turn reddish or reddish yellow in solution. Sulfates, expect greenish coloration and pH will not rise as quickly. Calcium, expect tannish and you may see bubbling during treatment, if carbonate related. This coloration may change during treatment which simply indicates a change in debris. The Catalyst is a polymer and silts may settle out of the chemistry sample which aids in development.
6. The well treatment would then be completed when,
 - a. pH does not rise,
 - b. When pH rises above 5 rapidly which indicates dilution of chemistry by fresh water moving through a cleaned production zone.
7. Bail or pump all debris from the very bottom of the well and divert acids away from the well into a tank for disposal. Pump until water is clear and pH is normal.

G. Final Downhole Video Survey

1. A downhole video survey shall be performed to visually inspect the integrity of the well, condition of production zone and blank, amount of fill and to determine the effectiveness of the rehabilitation.
2. A downhole video shall be performed with a full color camera with capabilities of a downhole view, side view with 360-degree rotation and digital depth counter accurate to +/- 1%. Downhole video shall be recorded either on a DVD or thumb drive for record.
3. The downhole video shall be performed to the satisfaction of the Engineer. It is recommended the survey perform a full 360-degree rotation every one (1) foot depth increment.
4. Contractor shall provide Engineer with a copy of the video.

H. Installation of Pumping Equipment

1. Contractor shall reinstall pumping equipment and replace any defective equipment for an additional cost as directed by Owner.
2. Contractor shall install the pumping equipment to industry standard which includes electrical connections, mechanically attaching power cable, 1.25 pvc access tube and airline to the column pipe.
3. After installation of the permanent pumping equipment is complete, Contractor shall disinfect in accordance with current AWWA standards for well disinfection. A bacteriological raw water sample shall be collected and submitted to a TCEQ approved lab by the Contractor. The Contractor shall secure a negative result before the well is placed into service.

I. Final Production Testing – Step Test

1. Production testing shall not proceed until static water levels are stable as indicated by two identical consecutive readings 30 minutes apart. Should stable conditions not occur, testing may commence after 4 hours of non-stable readings. Gauges used in the collection of water level data shall be accurate to 0.1 psi and not be over-pressured during the test. This may necessitate using different gauges during different portions of the test.
2. Water level measurement may be made by an approved pressure transducer set to record pressure at an interval no greater than one (1) minute. In no case shall water levels be measured with an airline. If measurements are taken by hand using an electric line, they shall conform to the following schedule for each step:

Prior to Test -	at 30-minute intervals for 4 hours unless stable
First 10 minutes -	at 1, 1.5, 2, 3, 4, 6, 8, and 10 minutes
From 10 - 120 minutes -	at 15, 20, 25, 30, 40, 60, 80, and 100 and 120 minutes
After 120 minutes -	at 1-hour intervals until completion of pumping or next step
After pumping ceases -	repeat the above schedule through 4 hours

3. Production testing shall be conducted for the same length of time as the initial test. Production testing may be shortened due to site specific conditions. Shortening of test must be approved by Engineer.
4. The test discharge shall be the same as in the initial test. The water flow rate measurement shall be made through a water meter with both cumulative gallons and instantaneous gallons per minute. The meter shall be furnished by the Contractor and acceptable to the Engineer. The flow rate shall be recorded together with the time of the measurement periodically through the test, and the discharge shall be adjusted to maintain a constant rate. The test shall be continuous.
5. The production test shall measure specific capacity.
6. Contractor shall provide Engineer with a copy of water level data and records of discharge.

END OF SECTION

SECTION 33 13 00 - DISINFECTION OF WATER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Work, material, and procedures for disinfection of installed potable water lines.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 1. American Water Works Association (AWWA):
 - a. AWWA B300, Hypochlorites.
 - b. AWWA B301, Liquid Chlorine.
 - c. AWWA B303, Sodium Chlorite.
 - d. AWWA C651, Disinfecting Water Mains.
 - e. AWWA C652, Disinfection of Water-Storage Facilities.
 - f. AWWA C653, Disinfection of Water Treatment Plants.
 - g. AWWA C654, Disinfection of Wells.

1.3 QUALITY CONTROL SUBMITTALS

- A. Submittals shall be made as required in the Front End Documents. The following specific information shall be provided:
 1. Procedures and plans for disinfection and testing.
 2. Type of disinfecting solution and method of preparation.

1.4 SEQUENCING AND SCHEDULING

- A. Commence disinfection after completion of following:
 1. Completion and acceptance of internal painting of system(s).
 2. Hydrostatic and pneumatic testing, pressure testing, functional and performance testing and acceptance of pipelines, pumping systems, structures, and equipment.

PART 2 - PRODUCTS

2.1 WATER FOR DISINFECTION AND TESTING

- A. Clean, uncontaminated, and potable.
- B. Owner will supply potable quality water; Contractor shall convey in disinfected pipelines or containers.

2.2 CONTRACTOR'S EQUIPMENT

- A. Furnish chemicals and equipment, such as pumps and hoses, to accomplish disinfection.

2.3 MIXING DISINFECTANT

- A. Prepare solution by mixing any of following as described below. The purpose of the stock solution is to facilitate mixing and dilution to ensure a uniform disinfecting solution. The Contractor will not be required to mix a stock solution if a liquid chlorine gas feed system that can accurately feed a desired amount of chlorine to mix a final (dilute) disinfecting solution is used.

1. Liquid chlorine gas conforming to AWWA B301 and water mixture.
 2. Dry chlorine gas conforming to AWWA B301.
 3. Calcium hypochlorite conforming to AWWA B300 or sodium hypochlorite conforming to AWWA B303 powder or liquid and water mixture.
- B. Feed dry chlorine gas through devices to regulate the rate of flow and ensure uniform diffusion of gas into water within the pipe or vessel being treated. Chlorinating devices for feeding chlorine gas solution or the gas itself shall prevent of water into chlorine cylinder.
- C. Use following proportions of hypochlorite or chlorine to water:
1. Chlorine Gas or Liquid (100 Percent Cl): 1 pound per 1 1.75 gallons water.
 - a. Apply liquid chlorine gas-water solution by means of a solution feed chlorinating device.
 2. Calcium Hypochlorite (65 to 70 Percent Cl): 1 pound per 7.5 gallons water.
 - a. If calcium hypochlorite is used, first mix dry powder with water to make a thick paste, then thin to a 1 percent solution (10,000 ppm chlorine).
 3. Sodium Hypochlorite (5.25 Percent Cl): 1 gallon per 4.25 gallons water.
 - a. If sodium hypochlorite procedure is used, dilute the liquid with water to obtain a 1 percent solution.

PART 3 - EXECUTION

3.1 GENERAL

- A. Disinfect pumps and pipelines, installed or modified under this Project, intended to hold, transport, or otherwise contact potable water:
1. Disinfect new pipelines that connect to existing pipelines up to the point of connection.
 2. Disinfect surfaces of materials that will contact finished water, both during and following construction using spray method described below.
 3. Disinfect prior to contact with finished water. Take care to avoid recontamination following disinfection.
- B. Prior to application of disinfectants, clean equipment and pipelines of loose and suspended material. Flush pipelines until clear of suspended solids and color. Use water suitable for flushing and disinfecting.
- C. Conform to AWWA C651 for pipes and pipelines, C652 for tanks and reservoirs, and AWWA C654 for wells, except as modified in these Specifications.
- D. Allow freshwater and stock disinfectant solution to flow into the pipe or vessel at a measured rate so that the chlorine-water solution is at the specified strength. Do not place concentrated commercial disinfectant in the pipeline or vessel before it is filled with water.

3.2 PIPING AND PIPELINES

- A. Flushing:
1. Before disinfecting, flush all foreign matter from pipeline. Provide hoses, temporary pipes, ditches, and other conduits as needed to dispose of flushing water without damage to adjacent properties. Flushing velocities shall be at least 2.5 fps. For large diameter pipe, where it is impractical or impossible to flush the pipe at specified velocity, clean the pipeline in-place from the inside by brushing and sweeping, then flush the line.
 2. Flush pipelines through flushing branches and remove branches after flushing is completed. Operate valves during flushing process at least twice during each flush.
 3. Flush service connections and hydrants. Flush distribution lines prior to flushing hydrants and service connections.

- B. Disinfecting Solution: Chlorine-water solution having a free chlorine concentration of not less than 50 ppm.
- C. Disinfecting Procedure: In accordance with AWWA C651, unless herein modified.
- D. Point of Application:
 1. Inject chlorine mixture into pipeline to be treated at beginning of line through corporation stop or suitable tap in top of pipeline.
 2. Control water from existing system to flow slowly into pipeline during application of chlorine.
 3. Control rate of chlorine solution flow in proportion to rate of water entering pipe so that combined mixture shall contain not less than 50 ppm of free available chlorine.
 4. Prevent of chlorine solution into line supplying water.
- E. Retention Period:
 1. Retain treated water in pipeline for at least 24 hours to destroy all nonspore-forming bacteria. At end of 24-hour period, disinfecting solution shall contain at least 10 ppm of free chlorine or the pipeline shall be recleaned, disinfecting solution shall be reapplied, and specified procedure repeated.
 2. Operate valves, hydrants, and appurtenances during disinfection to ensure that disinfecting solution is dispersed into all parts of pipeline, including dead-ends and areas that otherwise may not be treated.
 3. After disinfection, flush water from the permanent source until water through the pipeline is equal chemically and bacteriologically to permanent source of supply.

3.3 PUMPS

- A. Disinfecting Solutions: Minimum free chlorine concentration of 200 ppm.
- B. Disinfecting Procedure: In accordance with AWWA unless herein modified.
- C. Application:
 1. Inject the disinfecting solution into the pump and associated piping and circulate for a minimum 2-hour period of time. At the end of the 2-hour period, the solution shall have a strength of at least 100 ppm free chlorine.
 2. Operate valves and/or pump appurtenances during disinfection to ensure that the disinfecting solution is dispersed into all parts of the pumps and lines.
 3. If the disinfecting solution contained in the pumps has a residual free chlorine concentration less than 100 ppm after the 2-hour retention period, reclean the pump, reapply disinfecting solution, and retest until a satisfactory test result is obtained.
 4. After chlorination, flush the water from the pumps until the water through the units is chemically and bacteriologically equal to the permanent source of supply.

3.4 DISPOSAL OF DISINFECTING WASTEWATER

- A. Do not allow flow into a waterway without neutralizing disinfectant residual.
 1. See AWWA C652 for acceptable neutralization methods.

3.5 TESTING

- A. Test Equipment:
 1. Clean containers and equipment used in sampling and assure they are free of contamination.
 2. Obtain sampling bottles with instructions for handling from laboratory.

- B. Chlorine Concentration Sampling and Analysis:
 - 1. Sampling Frequency for Disinfecting Solution: Two samples per disinfecting procedure.
 - 2. Residual Free Chlorine Samples: Two samples per disinfecting procedure.
 - 3. Dechlorinated Disinfecting Wastewater Residual Samples: Two samples per disinfecting procedure.
 - 4. Sampling Locations: Each 1,000 feet of pipeline or each building.
 - 5. Analysis to be performed by the Owner's laboratory.

- C. After pipelines have been cleaned, disinfected, and refilled with potable water, Owner will take water Samples and have them analyzed for conformance to bacterial limitations for public drinking water supplies. Samples shall be analyzed for coliform concentrations in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater.
 - 1. A minimum of two Samples on each of 2 consecutive days from each separable structure every 1,000 feet of pipeline will be obtained and analyzed by standard procedures outlined by state and local regulatory agencies.

- D. If the minimum Samples required above are not bacterially negative, the disinfecting procedures and bacteriological testing shall be repeated on the respective facilities until bacterial limits are met.

END OF SECTION

SECTION 33 41 19 – PIPE LAYING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes the Work necessary to install gravity sewer, force main pipe, water pipe and appurtenances.
- B. Related sections:
 - 1. Section 31 23 16.16 – Trenching for Water and Sewer Lines
 - 2. Section 31 23 23.19 – Trench Bedding and Backfill for Water and Sewer Lines
 - 3. Section 33 11 11 – Piping Leakage Testing

1.2 GENERAL

- A. General Requirements: See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All pipe materials shall be as specified on the Plans and conforming to these specifications.

2.2 WARNING TAPE

- A. Non-metallic sanitary sewer marking tape shall be warning tape as manufactured by Rhino Marking and Protection Systems, Harris Industries, Inc., or approved equal.
- B. Tape shall have a minimum thickness of 4 mils and manufactured with heavy metal-free polyethylene tape that is impervious to all known alkalis, acids, chemical reagents, and solvents found in soil. The minimum overall width of the tape shall not be less than 3-inches. Standard rolls shall be 1000' length.
- C. The tape for sewer lines shall be color coded Green and imprinted with the following message: Caution Buried Sewer Line Below.
- D. The tape for water lines shall be color coded Blue and imprinted with the following message: Caution Buried Water Line Below.

2.3 TRACER WIRE

- A. Tracer wire shall be 12-gauge, stranded coated copper for underground burial.
- B. Jacket color shall be GREEN and made of High Density Polyethylene (HDPE) or High Molecular Weight Polyethylene (HMWPE) designed for direct burial.
- C. Connectors shall be used for all splices or repairs. Connectors shall be moisture displacement style as manufactured by 3M DBR, or equal.
- D. A locate or conductivity test shall be performed prior to signing off on the project.

2.4 PIPE BEDDING AND BACKFILL

- A. Shall be in accordance with 31 23 23.13.

PART 3 - EXECUTION

3.1 GENERAL

- A. All pipe, fittings, bedding, backfill, and all other appurtenances shall be installed in accordance with these specifications and the Plans.

3.2 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Delivery of Materials: Products shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.
- B. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.
- C. Pipe and accessories shall be handled in such a manner that will ensure their condition after installation to be sound and undamaged. Equipment, tools and methods used in unloading, reloading, hauling and laying pipe and fittings shall be such that they are not damaged. Under no circumstances shall loading forks, or other equipment, be inserted into the barrel of the pipe or fitting.
- D. Pipe having pre-molded joint rings shall be handled in such a manner that no weight, including the weight of the pipe itself, will bear on or be supported by the spigot rings at any time. Care shall be taken to avoid dragging the spigot ring on the ground or allowing it to come in contact with gravel, crushed stone, rocks, or other hard objects. Joint rings which have been damaged in any way will not be accepted and shall not be incorporated in the work.

3.3 FIELD QUALITY CONTROL

- A. Provide skilled workmen to insure embedment of pipe.
- B. Contractor shall test for defects and leakage as specified in Section 33 11 11.

3.4 TRACER WIRE

- A. Regardless of pipe material, a trace wire or coated metal strip shall be placed immediately above the initial backfill material and directly over the pipe. At valves, the trace wire shall be brought up into the valve box as indicated in the plans. A tracing test of trace wire will be required prior to final acceptance.

3.5 PIPE DETECTION TAPE

- A. Pipe detection tape shall be provided in all trenches for force main and water line construction. Installation shall be per manufacturer's recommendations and shall be as close as practical to finished grade while maintaining a required minimum of 18 inches between the detection tape and the top of any pipe.

3.6 LAYING PIPE

- A. Proper means and equipment shall be used for lowering pipe into the trenches.

- B. The Contractor shall have full responsibility for any diversion of drainage and for dewatering trenches.
- C. Recesses for the pipe bells are mandatory and shall be hand excavated so that the entire pipe barrel is uniformly supported by the bedding material.
- D. Pipe shall be protected from lateral displacement by means of pipe embedment material installed as provided in this specification. Under no circumstances shall pipe be laid in water and no pipe shall be laid under unsuitable weather or trench conditions.
- E. When jointed in the trench, the pipe shall form a true and smooth line. Pipe shall not be trimmed except for closures, and pipe not making a good fit shall be removed.
- F. Unless otherwise approved by the Engineer, the laying of pipe shall begin at the lowest point, and the pipe shall be installed so that the spigot ends point in the direction of flow.
- G. Pipe which is a part of a gravity sewer line shall be aligned and constructed to grades as shown on the plans. Lines not conforming to these grades shall be subject to removal and replacement at the Contractor's expense. Force main pipe shall match the horizontal alignment and shall closely match the grades shown on the plans.
- H. Pipelines or runs intended to be straight shall be laid straight.
- I. During installation, each pipe and fitting shall be inspected for defects. All defective, damaged, or unsound pipe and fittings shall be rejected and removed from the site of the work.
- J. Dependent on type of application, gravity or pressure, place thrust blocking at all pipe fittings, including bends and reducers, as shown on the Plans.
- K. Prior to joining the pipe, the plain ends of the pipe and the bells of the pipe shall be thoroughly cleaned using a soapy water and cloth, removing all foreign materials from the bells, especially the gasket seats. Any burrs or imperfections in that part of the plain end or bell which will be in contact with the gasket shall be removed.
- L. The clean gasket shall be inserted in the bell and a thin film of lubricant shall be applied to the inside surface of the gasket.
- M. The cleaned plain end shall initially be entered in the bell straight. The plain end shall be forced inside the gasket and bell until the limit mark is just visible. The pipe may then be deflected as allowed by the manufacturer.
- N. Lubricants shall be supplied by the pipe manufacturer in sufficient quantities. No substitutes shall be made.
- O. The Contractor shall furnish such jacks, or other devices as are necessary for forcing the pipe into the bell and gasket. Care shall be exercised to avoid damage to the pipe where the pushing device or machine part contacts the pipe. A wood block or suitable pad shall be placed between the pipe and that part of the pushing device which contacts the pipe.
- P. All plain ends that enter a push on bell shall be beveled at 30° for at least one eighth (1/8) inch. All cut pieces or ends of pipe of other classifications shall be so beveled.

3.7 PIPE BEDDING NON-FERROUS PIPE

- A. Non-ferrous pipe includes PVC, Polyethylene and FRP.

- B. Bedding material shall be as specified in Section 31 23 23.19.
- C. Place 6-inches, minimum, of bedding between excavated trench bottom or stabilized trench bottom and bottom of pipe or fitting. Provide depression in bedding for joints so that barrel of pipe or fitting rests on bedding. Place bedding in 6-inch maximum layers, compacted to 95% standard maximum density, to 6-inches over the top of pipe and fittings.
- D. Bedding is considered to be an integral part of the pipe installation. Therefore, particular care shall be given to ensure that bedding is in intimate contact with the pipe in all directions and that no portion of the bedding shall be compacted to less than the specified density, particularly the area below the springline of the pipe.
- E. Place bedding a minimum of 6-inches over the top of pipe and fittings. Bedding shall be compacted to 95% maximum density.
- F. For areas undercut, whether by Contractor's negligence or by direction of Engineer, provide and place crushed aggregate, compacted to 95% standard maximum density, to bottom elevation of pipe bedding.
- G. When used, the bottom of trench boxes will be above the level of pipe bedding before bedding is compacted. In no case will pipe bedding be compacted against the trench box or before the trench box is raised to allow compaction of bedding.

3.8 TRENCH BACKFILL

- A. Shall be as specified in Section 31 23 23.19.

3.9 ALIGNMENT AND GRADE

- A. All pipe shall be laid straight between changes in alignment, except as shown on the Plans, and at a uniform grade between changes in grade. All lines shall be laid so that each section between manholes will lamp.

3.10 JOINTING

- A. Boltless gasketed joints: All instructions and recommendations of the pipe manufacturer, relative to gasket installation and other jointing operations, shall be observed and followed by the Contractor. All joint surfaces shall be lubricated as recommended by the manufacturer immediately before the joint is completed.
- B. Mechanical joints: Mechanical joints shall be carefully assembled in accordance with the manufacturer's recommendations. If effective sealing is not obtained, the joint shall be disassembled, thoroughly cleaned and reassembled. Overtightening bolts to compensate for poor installation practice will not be permitted.

3.11 CUTTING PIPE

- A. Cutting of pipe shall be done in a neat manner, without damage to the pipe or to the lining therein. Pipe cuts shall be smooth, straight and at right angles to the pipe axis. All cutting of pipe shall be done with mechanical pipe cutters of an approved type except that in locations where the use of mechanical cutters would be difficult or impracticable, existing pipe may be cut with diamond point chisels, saws, or other tools which will cut the pipe without damaging impact or shock.

3.12 CLEANING

- A. The interior of all pipe shall be cleaned of all foreign matter before being installed and shall be kept clean until the work has been accepted. All lumps, blisters and excess coating shall be removed from exterior spigot and interior bell surfaces. Such surfaces shall be wire brushed and wiped clean, dry, and free from oil and grease before placing the spigot in the bell. All joint contact surfaces shall be kept clean until the jointing is completed.
- B. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being installed. No debris, tools, clothing, or other materials shall be placed in the pipe.
- C. Whenever pipe laying is stopped, the open end of the line shall be sealed with a watertight plug.

3.13 WATER AND SEWER LINE CROSSINGS

- A. Water and sewer lines crossing one another shall have a minimum 18-inch vertical separation.
- B. In general water lines shall be above sewer lines. However if water line cannot meet the 18-inch clearance above sewer line because of cover limitations or other obstructions, the water line may be above or below the sewer line but either the water or sewer line shall be encased 10 feet either side of the crossing line in steel encasement.
- C. Water lines shall not pass through manholes.

3.14 PARALLEL WATER AND SEWER LINES

- A. Water and sewer line shall have a minimum 10 feet horizontal separation.
- B. Water lines shall have a minimum 10-foot horizontal separation from sewer manholes.
- C. Water and sewer lines shall not be installed within the same trench.

3.15 CONNECTION OF NEW SEWER PIPELINES TO EXISTING SANITARY SEWERS

- A. Construct, clean, test, and obtain Engineer's approval for pipelines and manholes before connecting new pipeline to the existing sewer.
- B. If, in the opinion of the Engineer, conditions exist which require connection prior to final line acceptance, plug all lines entering the manhole connecting to the existing system until the new system is accepted. In addition, plug the line leaving the first manhole upstream. Never allow water being used to flush the new lines to enter the existing system.
- C. All new pipelines must connect to the existing system at a new or existing manhole. If a new manhole is built over an existing sewer line, do not break out the top of the existing pipe until the new line is accepted. Flexible pipe couplings, as manufactured by Fernco or equal, may be used to connect existing gravity sewer line to new gravity sewer lines as approved by the Engineer.
- D. If a new pipeline is to discharge into an existing manhole, divert the sewage flow around the existing manhole while the tie-in is under construction. Intercept the sewage flow at the existing manhole first upstream from the tie-in construction. Provide suitable pumping equipment and re-routing conduit to pump the sewage around the tie-in construction. Discharge into an appropriate manhole downstream from the construction.

- E. Connection to an existing manhole shall be made by core drilling. A concrete manhole adapter, A-LOK G3 boot system or equal, shall be installed on the sewer pipe, and the annular space grouted.
- F. Connect new pipelines to existing manholes in a neat, workmanlike manner, to ensure a watertight connection.

3.16 TRENCHING

- A. Pipe trenching shall be as specified in Section 31 23 23.19.

END OF SECTION

DIVISION 40
PROCESS INTEGRATION

SECTION 40 05 00 – PIPING SYSTEMS TESTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Test requirements for piping systems.
- B. Related Sections:
 - 1. Section 40 23 39 – Process Piping, General.

1.2 REFERENCES

- A. National Fuel Gas Code (NFGC):
 - 1. ANSI Z 223.1 or NFPA 54.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B31.8 – Gas Transmission and Distribution Piping Systems.
 - 2. B31.1 – Power Piping.
 - 3. B31.3 – Process Piping.

1.3 TESTING REQUIREMENTS

- A. General Requirements:
 - 1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 40 23 39; are specified in the specifications covering the various types of piping; and are specified herein.
 - 2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
 - 3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01 41 00, and UL requirements.
 - 4. Test Natural Gas or Digester Gas Piping:
 - a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01 41 00, or the National Fuel Gas Code, whichever is more stringent.
 - b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
 - 5. When testing with water, the specified test pressure is considered to be the pressure at the highest point of the piping section under test. Lower test pressure as necessary to prevent testing the lowest point above a safe test pressure.
- B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.
- C. Water for Testing, Cleaning, and Disinfecting:
 - 1. Water for testing, cleaning, and disinfecting shall be provided by the Contractor. The Owner may allow use of the water system on site when it is not shut down by work from this project.
- D. Pipes to be Tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

- E. Unsuccessful Tests:
 - 1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
 - 2. Repeat testing until tests are successful.
- F. Test Completion: Drain and leave piping clean after successful testing.
- G. Test Water Disposal: Dispose of testing water at the RPCF Sludge Handling Facility in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site.

1.4 SUBMITTALS

- A. Schedule and Notification of Tests:
 - 1. Submit a list of scheduled piping tests five (5) working days preceding the date of the scheduled tests.
 - 2. Notification of Readiness to Test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.5 SEQUENCE

- A. Clean piping before pressure or leak tests.
- B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.
- C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.
- D. Backfill and compact trench or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.
- E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING, ALIGNMENT, GRADE, AND DEFLECTION

- A. Alignment and Grade:
 - 1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
 - 2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.
- B. Deflection Test:
 - 1. Pull a mandrel through the clean piping section under test.
 - 2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
 - 3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within one percent plus or minus.

4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.2 AIR TESTING METHOD FOR PRESSURE PIPING

- A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.
- B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
 1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.
- C. Test at pressure as specified in Piping Schedule in Section 40 23 39:
 1. Provide temporary pressure relief valve for piping under test. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
 2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASCE B31.3, ASE B31.8, or the pipe manufacturer's stated maximum working pressure.
 3. Gradually increase test pressure to an initial test pressure equal to the lesser of one-half the test pressure or 25 pounds per square inch gauge.
 4. Perform initial check of joints and fittings for leakage.
 5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage at each step increase until test pressure reached.
 6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
 7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.3 TESTING GRAVITY FLOW PIPING

- A. Test Gravity Flow Piping indicated with "G" in the Piping Schedule, as follows:
 1. Unless specified otherwise, subject gravity flow piping to the following tests:
 - a. Alignment and grade.
 - b. For plastic piping test for deflection.
 - c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
 2. Inspect piping for visible leaks before backfilling. Provide temporary restraints when needed to prevent movement of piping. Pressure test piping with maximum leakage allowance after backfilling.
 3. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours.
 - a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
 - b. Maintain piping with water or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
 - c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of four hours while accurately measuring the volume of water added to maintain the test pressure.
 - 1). Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
 - a). For Concrete Piping with Rubber Gasket Joints: 80 gallons per day per inch of diameter per mile of piping under test.
 - (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.

- (2) For Vitrified Clay and Other Piping: 500 gallons per day per inch of diameter per mile of piping under test.

3.4 TESTING HIGH-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.
- B. General:
 1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
 2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
 3. Do not include valves, equipment or piping specialties in test sections if test pressure exceeds the valve, equipment or piping specialty safe test pressure allowed by the item's manufacturer.
 4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
 5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
 6. When test results indicate failure of selected sections, limit tests to piping:
 - a. Between valves.
 - b. Between a valve and the end of the piping.
 - c. Less than 500 feet long.
 7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.
- C. Testing Procedures:
 1. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Piping Schedule.
 2. Before pressurizing for the test, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
 3. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider visible leakage testing complete when no visible leaks are observed.
- D. Pressure Test with Maximum Leakage Allowance:
 1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
 2. Pressure test piping after completion of visible leaks test.
 3. For piping systems using joint designs other than flanged threaded or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
 - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
 - b. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
 - c. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
 - d. When leakage is allowed, calculate the allowable leakage by the following formula:

$$L = \frac{SD}{\sqrt{P}}$$

148,000

Where:

L = testing allowance (makeup water) (gph)

S = length of pipe tested (ft)

D = nominal diameter of the pipe (in.)

P = average test pressure during the hydrostatic test (psi [gauge])

3.5 TESTING LOW-HEAD PRESSURE PIPING

- A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.
- B. General:
1. Test pressures shall be as scheduled in Section 40 23 39.
 2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
 3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
 4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.
- C. Visible Leaks Test:
1. Subject piping under test to the specified pressure measured at the lowest end.
 2. Fill piping section under test slowly with water while venting air. Use potable water for all potable waterlines and where noted on the Piping Schedule.
 3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
 4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.
- D. Pressure Test with Maximum Leakage Allowance:
1. Pressure test piping after completion of visible leaks test.
 2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
 - a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours and no damage to piping and appurtenances has occurred.
 - b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
- E. Optional Joint Test:
1. When Joint Testing Is Allowed by Note in the Piping Schedule, the Procedure Shall Be as Follows:
 - a. Joint testing will be allowed only for low head pressure piping.
 2. Joint testing may be performed with water or air.
 3. Joint test piping after completion of backfill and compaction to the top of the trench.
 4. Joint Testing with Water:
 - a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
 - b. Maintain test pressure for one minute.
 - c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.

- d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
 - e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint Testing with Air:
- a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
 - b. Maintain test pressure for 2 minutes.
 - c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 40 05 13 - COMMON WORK RESULTS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies piping materials and installation methods common to more than one section of Division 40 and includes joining materials, piping specialties, and basic piping installation instructions.
- B. Related Sections:
 - 1. Piping materials and installation methods peculiar to individual systems are specified within their respective system specification sections of Division 40.
 - 2. Valves are specified in a separate section and in individual piping system sections of Division 40.
 - 3. Supports and Anchors are specified in a separate section of Division 40.
 - 4. Mechanical Identification is specified in a separate section of Division 40.
 - 5. Fire Barrier Penetration Seals are specified in Division 07.

1.2 SUBMITTALS

- A. Product Data: Submit product data on the following items:
 - 1. Escutcheons
 - 2. Dielectric Unions and Fittings
 - 3. Mechanical Sleeve Seals
- B. Quality Control Submittals:
 - 1. Submit welders' certificates specified in Quality Assurance below.

1.3 QUALITY ASSURANCE

- A. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
- B. Welding procedures and testing shall comply with ANSI Standard B31.1.0 - Standard Code for Pressure Piping, Power Piping, and The American Welding Society, Welding Handbook.
- C. Soldering and Brazing procedures shall conform to ANSI B9.1 Standard Safety Code for Mechanical Refrigeration.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
- B. Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
- C. Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, Manufacturers offering piping materials and specialties which may be incorporated in the work include, but are not limited to, the following:
- B. Pipe Escutcheons:
 - 1. Chicago Specialty Mfg. Co.
 - 2. Sanitary-Dash Mfg. Co.
 - 3. Grinnell
- C. Dielectric Waterway Fittings:
 - 1. Epco Sales, Inc.
 - 2. Victaulic Company of America
- D. Dielectric Unions:
 - 1. Eclipse, Inc.
 - 2. Perfection Corp.
 - 3. Watts Regulator Co.
- E. Mechanical Sleeve Seals:
 - 1. Thunderline Corp.

2.2 PIPE AND FITTINGS

- A. Refer to the individual piping system specification sections in Division 15 for specifications on piping and fittings relative to that particular system.

2.3 JOINING MATERIALS

- A. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.
- B. Brazing Materials: Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials appropriate for the materials being joined.
- C. Soldering Materials: Refer to individual piping system specifications for solder appropriate for each respective system.
- D. Gaskets for Flanged Joints: Gasket material shall be full-faced for cast-iron flanges and raised-face for steel flanges. Select materials to suit the service of the piping system in which installed and which conform to their respective ANSI Standard (A21.11, B16.20, or B16.21). Provide materials that will not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

2.4 PIPING SPECIALTIES

- A. Escutcheons: Chrome-plated, stamped steel, hinged, split-ring escutcheon, with set screw. Inside diameter shall closely fit pipe outside diameter or outside of pipe insulation where pipe is insulated. Outside diameter shall completely cover the opening in floors, walls, or ceilings.

- B. Unions: Malleable-iron, Class 150 for low pressure service and class 250 for high pressure service; hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.
- C. Dielectric Unions: Provide dielectric unions with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.
- D. Dielectric Waterway Fittings: electroplated steel or brass nipple, with an inert and non-corrosive, thermoplastic lining.
- E. Sleeves:
 1. Sheet-Metal Sleeves: 10 gauge, galvanized sheet metal, round tube closed with welded longitudinal joint.
 2. Steel Sleeves: Schedule 40 galvanized, welded steel pipe, ASTM A53, Grade A.
 3. Mechanical Sleeve Seals: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.

3.2 INSTALLATIONS

- A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated. Refer to individual system specifications for requirements for coordination drawing submittals.
 1. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated otherwise.
 2. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
 3. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Drawings.
 4. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
 5. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.
 6. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4" ball valve, and short 3/4" threaded nipple and cap.
- B. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6" shall be steel; pipe sleeves 6" and larger shall be sheet metal.

- C. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, or floors, the fire rated integrity shall be maintained. Refer to Division 07 for special sealers and materials.

3.3 FITTINGS AND SPECIALTIES

- A. Use fittings for all changes in direction and all branch connections.
- B. Remake leaking joints using new materials.
- C. Install strainers on the supply side of each control valve, pressure reducing or regulating valve, solenoid valve, and elsewhere as indicated.
- D. Install unions adjacent to each valve and at the final connection to each piece of equipment and plumbing fixture having 2" and smaller connections, and elsewhere as indicated.
- E. Install Flanges in piping 2-1/2" and larger, where indicated, adjacent to each valve, and at the final connection to each piece of equipment.
- F. Install dielectric unions to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air, vacuum).
- G. Install dielectric fittings to connect piping materials of dissimilar metals in wet piping systems (water, steam).

3.4 JOINTS

- A. Steel Pipe Joints:
 - 1. Pipe 2" and Smaller: Thread pipe with tapered pipe threads in accordance with ANSI B2.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended on the male threads at each joint and tighten joint to leave not more than 3 threads exposed.
 - 2. Pipe Larger Than 2": Weld pipe joints (except for exterior water service pipe) in accordance with ASME Code for Pressure Piping, B31.
 - 3. Weld pipe joints of exterior water service pipe in accordance with AWWA C206.
 - 4. Install flanges on all valves, apparatus, and equipment. Weld pipe flanges to pipe ends in accordance with ASME B31.1.0 Code for Pressure Piping. Clean flange faces and install gaskets. Tighten bolts to torque specified by manufacturer of flange and flange bolts, to provide uniform compression of gaskets.
- B. Non-ferrous Pipe Joints
 - 1. Brazed And Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ANSI B31.1.0 - Standard Code for Pressure Piping, Power Piping and ANSI B9.1 - Standard Safety Code for Mechanical Refrigeration.
 - 2. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine Emory cloth prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
- C. Mechanical Joints: Flared compression fittings may be used for refrigerant lines 3/4" and smaller.
- D. Joints for other piping materials are specified within the respective piping system sections.

3.5 FIELD QUALITY CONTROL

- A. Testing: Refer to individual piping system specification sections.

END OF SECTION

SECTION 40 23 39 - PROCESS PIPING - GENERAL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Basic Process Piping Materials, Methods, and Appurtenances.
- B. Related sections:
 - 1. Section 03 30 00 – Cast-In-Place Concrete.
 - 2. Section 09 90 00 – Painting and Protective Coatings.
 - 3. Section 31 23 23.19 – Trench Bedding and Backfill for Water and Sewer Lines.
 - 4. Section 33 11 11 – Piping Leakage Testing.
 - 5. Section 33 13 00 – Disinfection of Water Systems.
 - 6. Section 40 24 00 – Process Piping Specialties.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this Section and any supplemental Data Sheets:
 - 1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
 - 2. American National Standards Institute (ANSI):
 - a. A21.52, Ductile Iron Pipe, Centrifugally Cast, for Gas.
 - b. B1.20.1, Pipe Threads, General Purpose (Inch).
 - c. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
 - d. B16.3, Malleable Iron Threaded Fittings.
 - e. B16.5, Pipe Flanges and Flanged Fittings.
 - f. B16.9, Factory-Made Wrought Steel Butt Welding Fittings.
 - g. B16.11, Forged Fittings, Socket-Welding and Threaded.
 - h. B16.15, Cast Bronze 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 Class 150,300,400,600,900, 1500 and 2500.
 - l. B16.25, Butt Welding Ends.
 - m. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings, Classes 150 and 300.
 - 3. American Petroleum Institute (API): 5L, Specification for Line Pipe.
 - 4. American Society of Mechanical Engineers (ASME):
 - a. Boiler and Pressure Vessel Code, Section VITI, Division 1, Pressure Vessels.
 - b. Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
 - c. B31.1, Power Piping.
 - d. B31.3, Chemical Plant and Petroleum Refinery Piping.
 - e. B31.9, Building Services Piping.
 - f. B36.10M, Welded and Seamless Wrought Steel Pipe.
 - 5. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Nondestructive Testing Personnel Qualifications.
 - 6. American Society for Testing and Materials (ASTM):
 - a. A47, Standard Specification for Ferritic Malleable Iron Castings.
 - b. A53 Rev A, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - c. A105/ A105M, Standard Specification for Forgings, Carbon Steel, for Piping Components.
 - d. A106, 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, Standard Specification for Electric-Resistance-Welded Steel Pipe.
- g. A139 Rev A, Standard Specification for Electric-Fusion (Arc) -Welded Steel Pipe (NPS 4 and Over).
- h. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- i. A181/A181M Rev A, Standard Specification for Forgings, Carbon Steel, for General-Purpose Piping.
- j. A182/A182M Rev C, Standard Specification for Forged or Rolled Alloy-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 Rev A, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
- m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.
- n. A197, 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 Elevated Temperatures.
- q. A240, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.
- r. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
- s. A283/A283M Rev A, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
- t. A285/ A285M, Standard Specification for Pressure Vessel Plates, Carbon Steel, Low and Intermediate Tensile Strength.
- u. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
- v. A312/A312M, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
- w. A320/A320M, Standard Specification for Alloy Steel Bolting Materials for Low-Temperature Service.
- x. A395, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
- y. A403/ A403M Rev A, 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. 587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
- dd. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
- ee. A778 Rev A, Standard Specification for Welded, Un-annealed Austenitic Stainless Steel Tubular Products.
- ff. B32, Standard Specification for Solder Metal.
- gg. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
- hh. B61, Standard Specification for Steam or Valve Bronzed Casting.
- ii. B62, Standard Specification for Composition Bronzed or Ounce Metal Castings.
- jj. B75, Standard Specification for Seamless Copper Tube.
- kk. B88 Rev A, Standard Specification for Seamless Copper Water Tube.
- ll. B98, Standard Specification for Copper-Silicone Alloy Rod, Bar, and Shapes.

- mm. 582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
 - nn. D412, Standard Testing Method for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension.
 - oo. D413, Standard Testing Methods for Rubber Property-Adhesion to Flexible Substrate.
 - pp. D1248, Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
 - qq. D1784, Standard Specifications for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
 - rr. D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 - ss. D2000, Standard Classification System for Rubber Products in Automotive Applications.
 - tt. D2310, Standard Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
 - uu. D2464, Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 - vv. 2466, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 - ww. D2467, Standard Specification for Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 - xx. D2564, Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
 - yy. D2665, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe for Drain, Waste, and Vent Pipe and Fittings, Schedule 40.
 - zz. D2996, Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.
 - aaa. D3222 Rev A, Standard Specification for Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
 - bbb. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
 - ccc. D4101 Rev B, Standard Specification for Propylene Plastic Injection and Extrusion Materials.
 - ddd. F437, Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 - eee. F439 Rev A, Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
 - fff. F441, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
 - ggg. F491 Rev A, Standard Specification for Poly (Vinylidene Fluoride) (PVDF) Plastic-Lined, Ferrous Metal Pipes, and Fittings.
 - hhh. F493 Rev A, Standard Specification for Solvent Cements for Chlorinated Poly Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
 - iii. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) based on outside diameter.
7. American Welding Society (AWS):
 - a. A5.8, Specification for Filler Metals for Brazing and Braze Welding.
 - b. QC 1, Standard for AWS Certification of Welding Inspectors.
 8. American Water Works Association (AWWA):
 - a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 - b. C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3" through 48"for Water and Other Liquids.
 - c. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - d. C115/A21.15, Flanged Ductile-Iron Pipe with Threaded Flanges.
 - e. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.

- f. C153/A21.53, Ductile-Iron Compact Fittings 3" through 16", for Water and Other Liquids.
- g. C200, Steel Water Pipe – 6" and Larger.
- h. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4" and Larger-Shop Applied.
- i. C207, Steel Pipe Flanges for Water Works Service, Sizes 4" through 144".
- j. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
- k. C214, Fusion Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
- l. C606, Grooved and Shouldered Type Joints.
- m. M11, Steel Pipe - A Guide for Design and Installation.
- 9. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP 43, Wrought Stainless Steel Butt-Welding Fittings Including Reference to Other Corrosion Resistant Materials.
- 10. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.3 DEFINITIONS

- A. Submerged or Wetted:
 - 1. Zone below elevation of:
 - a. Top face of channel walls and cover slabs.
 - b. Top face of basin walkways.
 - c. Top face of clarifier walkways.
 - d. Top face of digester walls, including structure piping penetrations.
 - e. Liquid surface or within 2 feet above top of liquid surface.
 - f. Top of tank wall or under tank cover.

1.4 SUBMITTALS

- A. Shop Drawings:
 - 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. Gasket material, temperature rating, and pressure rating for each type of pipe and each type of service.
- B. Quality Control Submittals:
 - 1. Manufacturer's Certification of Compliance.
 - 2. Qualifications:
 - a. Weld Inspection and Testing Agency: Certification and qualifications.
 - b. Welding Inspector: Certification and qualifications.
 - c. Welders:
 - 1). List of qualified welders and welding operators.
 - 2). Current test records for qualified welder(s) and weld type(s) for factory and field welding.

3. Weld Procedures: Records in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
4. Nondestructive inspection and testing procedures.
5. Manufacturer's Certification of Compliance:
 - a. Pipe and fittings.
 - b. Factory applied resins and coatings.
6. Certified weld inspection and test reports.
7. Test logs.

1.5 QUALITY ASSURANCE

- A. Weld Inspection and Testing Laboratory Qualifications:
 1. Retain approved independent testing laboratory that will provide the services of an AWS certified welding inspector qualified in accordance with AWS QC1 with prior inspection experience of welds specified herein.
 2. Perform weld examinations with qualified testing personnel who will carry out radiography, ultrasonic, magnetic particle, and other nondestructive testing methods as specified herein.
 3. Welding Inspector:
 - a. Be present when shop or field welding is performed to certify that welding is in accordance with specified standards and requirements.
 - b. Duties include, but are not limited to, the following:
 - 1). Job material verification and storage.
 - 2). Qualification of welders.
 - 3). Certify conformance with approved welding procedure specifications.
 - 4). Maintain records and prepare reports in a timely manner.
 - 5). Notify Engineer within 1 hour of discovery of unsatisfactory weld performance and within 24 hours of weld test failure.
 - 6). Supervision of testing personnel.
- B. Welder and Welding Operator Performance:
 1. Qualify welders and welding operators by approved testing laboratory before performing any welding under this section.
 2. Perform welder qualification tests in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code.
 3. Qualification tests may be waived if evidence of prior qualification is deemed suitable by the Engineer.
 4. Qualify welders and operators in the performance of making groove welds in each different pipe material, including carbon steel pipe, in Positions 2G and 5G for each welding process to be used.
 5. Qualify welders and welding operators for stainless steel as stated herein on the type of stainless steel being welded with the welding process used.
- C. Certifications:
 1. Coal-Tar Epoxy Applicator: Certified by Piping Manufacturer to be qualified to apply coal-tar epoxy coating to submerged or embedded ductile iron or cast iron soil piping.
 2. Weld Testing Agency: Certified in accordance with current American Society for Nondestructive Testing (4153 Arlingate Plaza, Columbus, OH 43228) recommended practice SNT-TC-1A, NDT Level II.
- D. Quality Control Submittals:
 1. Manufacturer's Certification of Compliance.
 2. Laboratory Testing Equipment: Certified calibrations, Manufacturer's product data, and test procedures.
 3. Certified welding inspection and test results.
 4. Qualifications:

- a. Weld Inspection and Testing Agency: Certification and qualifications.
- b. Welding Inspector: Certification and qualifications.
- c. Welders:
 - 1). List of qualified welders and welding operators.
 - 2). Current test records for qualified welder(s) and weld type(s) for factory and field welding.
- 5. Weld Procedures: Records 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. Manufacturer's Certification of Compliance:
 - a. Pipe and fittings.
 - b. Welding electrodes and filler materials.
 - c. Factory applied resins and coatings.
- 8. Certified weld inspection and test reports.
- 9. Pipe coating applicator certification.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. As shown below or as recommended by manufacturer.
 - 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

2.1 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 836.10M.
 - 3. Cement-Lined Steel Pipe: Lining inside diameter.

2.2 JOINTS

- A. Grooved End System:
 - 1. Rigid, except where joints are used to correct misalignment, to provide flexibility, or where shown, furnish flexible type.
 - 2. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.
- B. Flanged Joints:
 - 1. Flanges for ductile iron pipe shall conform to AWWA C115 at pressure rating meeting requirements of the connecting piping.
 - 2. Flanges for steel pipe shall conform to ANSI/ASME B16.5 at pressure rating meeting requirements of the connecting piping
 - 3. 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 ANSI B 1.20. 1.

- D. Thrust Tie-Rod Assemblies: NFPA 24; tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.
- E. Mechanical Joint Anchor Gland Follower:
 - 1. Ductile iron anchor type, wedge action, with break off tightening bolts.
 - 2. Manufacturer and Product: EBAA Iron Inc.; Megalug.
- F. Flexible Mechanical Compression Joint Coupling:
 - 1. Stainless steel, ASTM A276, Type 305 bands.
 - 2. Manufacturers:
 - a. Pipeline Products Corp.
 - b. Ferno Joint Sealer Co.
 - c. Engineer approved equal
- G. Mechanical connections of the 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. A polyethylene stub end thermally butt-fused to the end of the pipe.
 - 2. ASTM A240, Type 304 stainless steel backing flange, 125-pound, ANSI B16.1 Standard. Insulating flanges shall be used where shown.
 - 3. Bolts and nuts of sufficient length to show a minimum of three complete threads when the joint is made and tightened to the Manufacturer's standard. Re-torque the nuts after 4 hours.
 - 4. Gaskets as specified on Data Sheet.
 - 5. Connection to buried mechanical joint fittings and valves shall be by restrained mechanical joint follower glad designed for HDPE pipe. Provide stainless steel stiffener as required by pipe manufacturer.

2.3 COUPLINGS

- A. Steel Middle Rings and Followers:
 - 1. Fusion bonded, epoxy-lined, and coated in accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.
- B. Flexible Couplings:
 - 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1). Unrestrained:
 - a. Dresser; Style 38.
 - b. Smith-Blair; Style 411.
 - c. Romac 501
 - b. Restrained PVC Pipe:
 - a. Smith-Blair; Style 472
 - b. Romac Armor Lock
- C. Transition Couplings:
 - 1. Manufacturers and Products:
 - a. Dresser; Style 62.
 - b. Smith-Blair; Style 413.
 - c. Romac RC501
- D. Flanged Coupling Adapters:
 - 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1). Smith-Blair; Series 913.
 - 2). Dresser Industries, Inc.; Style 128-W.

- 3). Romac FC400
 - b. Ductile Iron Pipe:
 - 1). Smith-Blair; Series 912.
 - 2). Dresser Industries, Inc.; Style 128-W.
 - 3). Romac FCA501
 - c. PVC Pipe:
 - 1). Romac RFCA-PVC
 - E. Dismantling Joints:
 - 1. Manufacturers and Products:
 - a. Steel or Ductile Iron Pipe:
 - 1). Smith-Blair; Series 975.
 - 2). Dresser Industries, Inc.; Style 131.
 - 3). Romac DJ400.
- 2.4 HARDWARE
- A. All hardware on submerged piping or piping below the top elevation of tanks and directly exposed to water, wastewater and/or wastewater solids , including but not limited to bolts, nuts, washers, and threaded rod shall be stainless steel.
- 2.5 GASKET LUBRICANT
- A. Lubricant shall be supplied by pipe Manufacturer and no substitute or “or-equal” will be allowed.
- 2.6 DOUBLE WALL CONTAINMENT PIPING SYSTEM
- A. All system components shall be pre-engineered, factory fabricated, tested, and assembled such that field assembly is minimized to primarily that of straight joints.
- 2.7 THRUST RESTRAINT
- A. Buried piping shall be restrained joint piping unless specified otherwise or when connecting to existing pipe lines. When connecting to existing pipe lines concrete thrust blocking shall be used as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.
 - B. All above grade piping shall be adequately restrained and supported.
- 2.8 VENT AND DRAIN VALVES
- A. Pipeline 2-1/2” Diameter and Larger: Vent connections shall be 3/4-inch with V300 ball valve. Drain connection shall be 1-inch with V300 ball valve, unless shown otherwise.
 - B. Pipeline 2” Diameter and Smaller: Vent connections shall be 1/2-inch with V300 ball valve. Drain connection shall be 1-inch with V300 ball valve, unless shown otherwise.
 - C. Provide galvanized steel pipe plug in each ball valve.
- 2.9 FABRICATION
- A. Mark each pipe length on outside:
 - 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. Flanged pipe shall be fabricated in the shop, not in the field, and delivered to the site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by the Manufacturer.

2.10 FINISHES

- A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s), Piping Schedule, and Section 09 90 00, PAINTING AND PROTECTIVE COATINGS.
- B. Galvanizing:
 - 1. Hot-dip applied, meeting requirements of ASTM A153.
 - 2. Electroplated zinc or cadmium plating is unacceptable.
 - 3. Stainless steel components may be substituted where galvanizing is specified.

2.11 SPECIALTIES

- A. Dielectric Unions: Provide dielectric unions with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

PART 3 - EXECUTION

3.1 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.
- C. Welding Electrodes: Verify proper grade and type, free of moisture and dampness, and coating is undamaged.

3.2 PREPARATION

- A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.
- B. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.
- C. 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 the site.

3.3 WELDING

- A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.1 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting Manufacturer.
- B. Weld Identification: Mark each weld with symbol identifying welder.
- 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: ANSI 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", whichever is greater.
- F. Climatic Conditions:
1. Do not perform welding if there is impingement of any rain, snow, sleet or high wind on the weld area, or if the ambient temperature is below 32 °F.
 2. Stainless Steel and Alloy Piping: If the ambient is less than 32° F, local preheating to a temperature warm to the hand is required.
- 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 Passes: As required in welding procedure.
- J. Weld Quality: Free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity slag inclusions, and other defects in excess of limits shown in applicable piping code.

3.4 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. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
- D. Threaded and Coupled Joints:
1. Conform to ANSI 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. 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 non-corrosive 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.
- F. Couplings:
1. General:
 - a. Install in accordance with Manufacturer's written instructions.
 - b. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
 - c. Remove pipe coating if necessary to present smooth surface.
 2. Application:
 - a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
 - b. Nonmetallic Piping Systems: Teflon bellows connector.
 - c. Concrete Encased Couplings: Sleeve type coupling.
 - d. Corrosive Service Piping: Elastomer bellows connector.
 - e. Grit Slurry Piping: Elastomer bellows connector.
- G. Pipe Connections at Concrete Structures: As specified in article PIPING FLEXIBILITY PROVISIONS in Section 40 24 00, PROCESS PIPING SPECIALTIES.
- H. Penetrations:
1. Watertight Penetrations:
 - a. Provide wall pipes with thrust collars, as specified in Section 40 24 00, PROCESS PIPING SPECIALTIES.
 - b. Provide taps for stud bolts in flanges to be set flush with wall face.
 2. Non-watertight Penetrations:
 - a. Pipe sleeves with seep ring as specified in Section 40 24 00, PROCESS PIPING SPECIALTIES.
 - b. Pipe sleeves with modular mechanical seal may be provided where fabrication of seep ring on pipe sleeve is impractical.
 3. Existing Walls:
 - a. Rotary drilled holes with modular mechanical seal as specified in Section 40 24 00, PROCESS PIPING SPECIALTIES.
 4. Fire-Rated or Smoke-Rated Walls, Floor, or Ceilings: Insulated and encased pipe sleeves as specified in Section 40 24 00, 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 over tighten fittings.
 3. Do not thread Schedule 40 pipe.
- J. Ductile Iron, Cement-Lined Ductile Iron, and Glass-Lined Ductile Iron Piping:
1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive saw 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.

3.5 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 22 05 29, PROCESS SUPPORTS AND ANCHORS.
- C. Group piping wherever practical at common elevations; installing 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' 6", 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' 0", 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 1" 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. Head room 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.

3.6 INSTALLATION-BURIED PIPE

- A. Joints:
 1. Dissimilar Buried Pipes:
 - a. Provide flexible mechanical compression joints for pressure pipe.
 - b. Provide concrete closure collar for gravity and low 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 23.16, 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 pipe section laid when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in the direction the pipe is 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. PVC and CPVC Pipe Placement:

1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by Manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 °F, or above 90 °F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:

1. Deflection from Horizontal Line, Except PVC, CPVC, or HDPE: Maximum 2".
2. Deflection from Vertical Grade: Maximum 1/4".
3. Joint Deflection: Maximum of 75% of Manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75' from position shown.
5. Pipe Cover: Minimum 5', unless otherwise shown.

3.7 THRUST RESTRAINT

A. Location:

1. Buried Piping: At pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist.
2. Exposed Piping: At all joints in pressure piping.

B. Thrust Ties:

1. Install as detailed.
2. Anchoring retainer glands or thrust ties with setscrews is unacceptable.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint Manufacturer's adapter gland follower and pipe end retainer, or thrust tie-rods and socket clamps.

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.

3.8 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 the 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 a tapping boss of a fitting, valve body, or equipment casting.
 2. Welded Steel or Alloy Piping: Connect only with welded thread-o-let or half-coupling as specified on Piping Data Sheet.
 3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.9 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 the vents on high points, and drains on low points of pipelines, whether shown or not.

3.10 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 plant process air, natural gas, and instrument air-lines with compressed air at 4,000 fpm; do not flush with water.
- C. 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.
- D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.
- E. Remove accumulated debris through drains 2" and larger or by removing spools and valves from piping.

3.11 DISINFECTION

- A. Disinfect pipelines intended to carry potable water (W1).
- B. See Section 33 13 00, DISINFECTION OF WATER SYSTEMS.

3.12 FIELD FINISHING

- A. Notify Engineer at least 3 days prior to start of any surface preparation or coating application work.

3.13 FIELD QUALITY CONTROL

- A. Pressure Leakage Testing: As specified. See Section 33 11 11, PIPING LEAKAGE TESTING.
- B. Minimum Duties of Welding Inspector:
 - 1. Job material verification and storage
 - 2. Qualifications 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 ASME B31.1.
 - 2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for all piping covered by this section.
 - 3. Examine at least one of each type and position of weld made by each welder or welder operator.
 - 4. For each weld found to be defective under the acceptable 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 3. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.14 SUPPLEMENTS

- A. The supplements listed below, following "END OF SECTION," are a part of this Specification.
 - 1. Piping Schedule.
 - 2. Data Sheets.

Number	Title
40 23 39.13	Polyvinyl Chloride (PVC) Pipe and Fittings

END OF SECTION

PROCESS PIPING SCHEDULE

Service	Flow Stream Identifier	Installation (Note 1)	Nominal Diameter (Note 2)	Material (Note 3)	Coating (Note 8)	Spec / Data Sheet No.	Max Operating Temp (°F)	Max Operating Pressure (psig)	Test Pressure (psig) & Method (Note 4)	Pipe Color (Note 5)	Remarks
Potable Water	W1	Exposed Buried	All	SST SST	None	44 42 56.31 Part 2.5	Ambient	55	100, H		2
Potable Water	W1	Buried	All	Sch 80 PVC	None	40 23 39.43	Ambient	55	100, H		2

Notes:	<p>1 Encased – Concrete encase piping as indicated on the drawings.</p> <p>2 > Greater Than < Less Than <= Less Than or Equal To >= Greater Than or Equal To</p> <p>3 BS – Black Steel CLDI – Cement Lined Ductile Iron PVC- Polyvinyl Chloride CPVC - Chlorinated Polyvinyl Chloride CU – Copper HDPE – High Density Polyethylene SST - Stainless Steel FL PVC – Flanged Polyvinyl Chloride Pipe PO PVC – Push on Joint Polyvinyl Chloride Pipe SW PVC – Solvent Weld Polyvinyl Chloride Pipe</p>	<p>4 H - Hydrostatic Test P - Pneumatic Test G - Gravity Piping AM – Air Method HH – High Head LH – Low Head LP – Low-Pressure Pneumatic Test See Section 33 11 11 for Piping Leakage Testing requirements, for systems specified in Division 33. See Section 40 05 00 for Piping Leaking Testing requirements for systems specified in Division 40.</p> <p>5 Pipe testing required as specified above. No painting is required for buried PVC or SST pipe. For buried piping, no color shall be required; coordinate for proper coatings, as necessary. Where no color is indicated, color to be selected by Owner. For exposed piping not coated, provide colored banding and identification.</p> <p>6 General - Deviations from this schedule are indicated directly by note on Drawings where deviation is required.</p> <p>7 General – The piping material shall conform to the requirements for the service listed being drained or vented.</p> <p>8 EPP – Epoxy and Polyurethane Coating System HSE – High Solids Epoxy CTP – Coal Tar Pitch HT – High Temperature</p>
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Remarks:	<p>1 Where buried piping transitions to exposed PVC piping, the buried piping shall be extended at least six (6) inches above the finished floor before transitioning to exposed PVC piping. Exposed PVC piping shall continue to the connection of SST piping using a flanged coupling adapter.</p> <p>2 Buried raw water piping between the ground storage tank and pump station and also the pump station and hydropneumatic tanks shall be Sch 80 PVC. All pipe within the booster pump station shall be SST.</p> <p>3 Booster pump station piping shall transition from SST to Sch. 80 PVC below the vertical 90 degree bends inside the booster pump stations.</p>
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**SECTION 40 23 39.13
DUCTILE IRON PIPE AND FITTINGS**

Item	Description
Pipe	<p>Buried Liquid Service: Push-On, Mechanical, or Proprietary Restrained Joints: AWWA C110/A21.10-93, AWWA C115/A21.15-88, and AWWA C151/A21.51-91, pressure class conforming to Tables 51.1 and 51.3 for Type 4 trench, 250 psi minimum working pressure.</p> <p>Exposed Pipe: Grooved End or Flange Joints: AWWA C115/A21.15-88, and AWWA C151/A21.51-91, thickness Class 53 minimum conforming to Table 51.7, 250 psi minimum working pressure.</p>
Coating	<p>Buried Pipe: Exterior coating used under normal conditions shall be an asphaltic coating approximately 1 mil (25 µm) thick and per AWWA C151/A21.51-17.</p> <p>Exposed Pipe: Shall be as indicated in the schedule.</p>
Encasement	<p>Polyethylene encasement shall be used on all underground ductile iron pipe, fittings, valves, and appurtenances. See Specification Section 40 42 13.16 – POLYETHYLENE ENCASEMENT FOR DUCTILE IRON AND CAST IRON PIPE.</p>
Lining	<p>Lining shall be Cement-Mortar AWWA C104/A21.4-90 unless noted otherwise.</p> <p>Ceramic Epoxy Protecto 401 or equal shall be used where indicated in the pipe schedule.</p> <p>Glass Lining: VITCO Corp. SG-14 or equal shall be used where indicated in the schedule.</p> <p>Linings for fittings shall be as indicated below.</p>
Joints	<p>Push-On: 250 psi minimum working pressure, AWWA C110/A21.10-93 and C111/A21.11-90. American Cast Iron Pipe Co., Fastite Joints; U.S. Pipe and Foundry, Tyton Joint.</p> <p>Mechanical: 250 psi minimum working pressure, AWWA C111. American Cast Iron Pipe Co., Mechanical Joint; U.S. Pipe and Foundry, Mechanical Joint.</p> <p>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.</p> <p>Grooved End: Rigid type radius cut conforming to AWWA C606-87, 250 psi minimum working pressure. Victaulic; Gustin-Bacon.</p> <p>Flange: 125-pound flat face, 250-pound raised face, ductile iron, threaded conforming to AWWA C115/A21-15.88. Gray cast iron will not be allowed.</p>

**SECTION 40 23 39.13
DUCTILE IRON PIPE AND FITTINGS**

Item	Description
Fittings	<p>Push-On: AWWA C110/A21.10-93 and C111/A21.11-90, gray or ductile iron, 250 psi minimum working pressure. American Cast Iron Pipe Co., Fastite Joints; U.S. Pipe and Foundry, Tyton Joint.</p> <p>Mechanical Joint: For Buried Service. AWWA C110/A21.10-93, C111/A21.11-90, and C153/A21.53-88 gray or ductile iron, 250 psi minimum working pressure. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. American Cast Iron Pipe Co., Mechanical Joint; U.S. Pipe and Foundry, Mechanical Joint.</p> <p>Proprietary Restrained Joint: AWWA C111/A21.11-90 and C153/A21.53-88, ductile iron, 250 psi minimum working pressure. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116. Clow Corp., Super-Lock Joint; American Cast Iron Pipe Co., Flex-Ring or Lok-Ring Joint; U.S. Pipe, TR Flex.</p> <p>Proprietary Restrained River Crossing: Clow Ball and Socket; U.S. Pipe Usiflex. Coating/lining shall be Fusion-Bonded Epoxy meeting AWWA C116.</p> <p>Grooved End: AWWA C606-87 and C110/A21.10-93, ductile iron, 250 psi minimum working pressure. Lining and coating shall match connecting pipe. Victaulic; Gustin-Bacon.</p> <p>Flange: AWWA C110/A21.10-93 and ANSI B16.1-89, ductile or gray cast iron, faced and drilled, 125-pound flat face or 250-pound raised face. Gray cast iron will not be allowed. Lining and coating shall match connecting pipe.</p>
Couplings	<p>Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47-90 or ductile iron per ASTM A536-84. Victaulic; Gustin-Bacon.</p> <p>Grooved End Adapter Flanges: 250-pound malleable iron per ASTM A47-90 or ductile iron per ASTM A536-84. Victaulic; Gustin-Bacon.</p>
Bolting	<p>Mechanical, Proprietary Restrained, and Grooved End Joints: 316 Stainless Steel Hardware.</p> <p>125-pound Flat-Faced Flange: Exposed piping - ASTM A307-94, Grade A carbon steel hex head bolts and ASTM A563-93, Grade A steel hex head nuts.</p> <p>250-pound Raised-Face Flange: Exposed piping - ASTM A307-94, Grade B carbon steel hex head bolts and ASTM A563-93, Grade A carbon steel heavy hex head nuts.</p> <p>All hardware on submerged piping or piping below the top elevation of tanks and directly exposed to water, wastewater and/or wastewater solids, including but not limited to bolts, nuts, washers, and threaded rod shall be stainless steel.</p>

**SECTION 40 23 39.13
DUCTILE IRON PIPE AND FITTINGS**

Item	Description
Gaskets	<p>Mechanical, and Proprietary Restrained Joints, Water and Sewage: Rubber conforming to ANSI/AWWA C111/A21.11-90 Locking gaskets produced in accordance with AWWA C111 are acceptable for use as a joint restraint mechanism for buried push-on type joints. Locking gaskets shall be rated for the same working pressure as the pipe. American Cast Iron Pipe Co., Fast-Grip Gasket; US Pipe, Field LOK Gaskets.</p> <p>Mechanical and Proprietary Restrained Joints, Air: Viton, Fluorel, or Manufacturer's standard for high temperature air service, rated to 300 degrees F minimum, conforming to ANSI/AWWA C111/A21.11-90</p> <p>Grooved End Joints: Halogenated butyl conforming to ASTM D2000-90 and AWWA C606-87. Gaskets for air service shall be pressure-responsive synthetic rubber, rated to 300 degrees F minimum, conforming to ASTM D2000.</p> <p>Flanged, Water and Sewage Services: 1/8-inch thick, unless otherwise specified, homogenous black rubber (EPDM), hardness 60 (Shore A), rated to 212 degrees F., conforming to ANSI B16.21 and ASTM D1330 Steam Grade.</p> <p>Flanged, Air Service: 1/8-inch thick, unless otherwise specified, Teflon, PTFE, or compressed inorganic fiber with nitrile binder, rated to 300 degrees F. minimum, conforming to ANSI B16.21 and ASTM D1330.</p> <p>Ring gaskets shall not be permitted.</p> <p>Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange.</p> <p>Gasket pressure rating equal to the pressure rating as the pipe or fitting.</p>
Joint Lubricant	Manufacturer's Standard.

END OF SECTION

**SECTION 40 23 39.43
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS**

Item	Size	Description
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 23447-B conforming to ASTM D1785-05. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule 80 PVC as specified above: Conforming to the requirements of ASTM D2467.
Joints	All	Solvent socket-weld except where connection to valves and equipment may require future disassembly. Threaded joints shall not be used unless specifically approved by ENGINEER
Flanges	All	One piece, molded hub type PVC flat face flange in accordance with Fittings above, 125-pound ANSI B16.1-89 drilling.
Bolting	All	Flat Face Mating Flange or In Corrosive Areas: ASTM A193/A193M Rev A-94 Type 316 stainless steel Grade B8M hex head bolts and ASTM A194/A194M-94 Grade 8M hex head nuts. With Raised Face Mating Flange: Carbon steel ASTM A307-94 Grade B square head bolts and ASTM A563-93 Grade A heavy hex head nuts.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8" thick. Raised Face Mating Flange: Flat ring 1/8" thick, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment. Gasket material shall be suitable for each service. Submit recommended gasket material for each service to ENGINEER.
Solvent Cement	All	As recommended by the pipe and fitting manufacturer conforming to ASTM F493 Rev A. Solvent cement shall be rated for use with each service. Provide manufacturer's certification that the solvent is appropriate for respective service.
Thread Lubricant	All	Teflon Tape

END OF SECTION

SECTION 40 23 43 - PROCESS VALVES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Basic requirements for Process Valves.
- B. Related sections:
 - 1. Section 40 23 39 – Process Piping - General.

1.2 GENERAL

- A. See Section 40 23 39, PROCESS PIPING - GENERAL, which contains information and requirements that apply to the work specified herein and are mandatory for this project.
- B. Certain valves are specified in Division 44 to be furnished by equipment manufacturer as part of their equipment package and/or system. These valves are to be installed by the Contractor as specified herein. In addition to installation, the Contractor shall be responsible for test, inspection, and assisting the equipment suppliers in start-up services as required to the place the valves into continuous, reliable operation.

1.3 SUBMITTALS

Provide submittal for approval as specified in Section 8.3, SUBMITTALS of Uniform General Conditions for State of Texas Construction Contracts. The following specific information shall be provided:

- 1. Shop Drawings:
 - a. Product data sheets for make and model.
 - b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Refer to specific valve type for additional submittal requirements.
- 2. Quality Control Submittals:
 - a. Tests and inspection data.
 - b. Manufacturer's Certificate of Proper Installation.
 - c. Manufacturer's printed installation instructions.
 - d. Special shipping, storage and protection, and handling instructions.
 - e. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
 - f. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.

1.4 OPERATION AND MAINTENANCE DATA

- A. O&M Manuals and Maintenance Summary Forms: As specified in Uniform General Conditions for State of Texas Construction Contracts.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Valve to include operator, actuator, hand wheel, chain wheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, and accessories for a complete operation.

- B. Valve shall be suitable for intended service. Renewable parts not to be of a lower quality than specified.
- C. Valve shall be the same size as adjoining pipe.
- D. Valve ends to suit adjacent piping.
- E. Valve shall open by turning counterclockwise unless otherwise specified.
- F. Operator, actuator, and accessories shall be factory mounted.
- G. EFFECTIVE JANUARY 4, 2014 ANY VALVE, PIPE, FITTING, SOLDER, OR FLUX USED OR IN CONTACT WITH POTABLE WATER MUST COMPLY WITH THE REDUCTION OF LEAD IN DRINKING WATER ACT, AN AMENDMENT TO SECTION 1417 OF THE SAFE DRINKING WATER ACT (SDWA). VALVES SPECIFIED IN THIS SECTION MAY NOT MEET REQUIRMENTS OF THIS ACT, HOWEVER THIS DOES NOT RELIEVE THE CONTRACTOR FROM PROVIDING A VALVE TO MEET REQUIREMENTS OF THE (SDWA) AND THE SAME FUNCTIONAL REQUIREMENTS OF THIS SPECIFICATION.

2.2 SCHEDULE

- A. Requirements relative to this section for certain type of actuated or process valves are shown on the Valve Schedules attached as Supplements to the related Sections.

2.3 MATERIALS

- A. Brass and bronze valve components and accessories that have surfaces in contact with water shall be alloys containing less than 16% zinc and 2% aluminum.
- B. Approved alloys are of the following ASTM designations:
 1. B61, B62, B98 (Alloy UNS No.C65100, C65500, or C66100), B139 (Alloy UNS No.C51000), B584 (Alloy UNS No.C90300 or C94700), B164, B194, and B127.
 2. Stainless steel, AISI Type 316 may be substituted for bronze.

2.4 FACTORY FINISHING

- A. Epoxy Lining and Coating:
 1. In accordance with AWWA C550 unless otherwise specified. Coating shall be either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as "fusion" or "fusion bonded" epoxy.
 2. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.
- B. Exposed Valves Field Finish:
 1. Final paint coating shall be in accordance with Section 09 90 00, PAINTING AND PROTECTIVE COATINGS. System and color shall match adjacent piping system.
 2. Safety isolation valves and lockout valves with handles, hand wheels, or chain wheels "safety yellow."

2.5 VALVES

- A. Gate Valves:
 1. Type V140: Gate Valve, Less Than 3 Inches
 - a. General:
 - 1) Service: Aboveground, clean water and air.
 - 2) 150 psi Class

- 3) Rising Stem type
 - 4) Threaded ends
 - 5) Conform to MSS-SP-80, Type 2
 - b. Materials:
 - 1) Body & bonnet: Bronze, ASTM B62 alloy C83600
 - 2) Disc: Bronze, ASTM B62 alloy C83600
 - 3) Stem: ASTM B505 alloy C83600 or ASTM B371 alloy C69400
 - c. Manufacturers and Products:
 - 1) Crane – Figure 431.
 - 2) Jenkins – Figure 2810J
 - 3) Nibco – T-131
 - 4) Or engineer approved equal.
2. Type V141: Buried Gate Valve, 3 Inches and Larger
- a. Valve shall be resilient wedge type, of non-rising stem design and rated for 250 psig cold water working pressure.
 - b. Valve shall meet or exceed all requirements of the latest revision of AWWA C515.
 - c. Valve ends shall match pipe material ends and be approved by Engineer.
 - d. Stem shall be sealed by three O-Rings. O-Rings set in a cartridge shall not be allowed.
 - e. Each valve shall have maker's name, pressure rating, and year in which it was manufactured cast in the body. Country of origin to be clearly cast into body & cover castings.
 - f. Materials:
 - 1) All cast ferrous components shall be ductile iron, ASTM A536.
 - 2) The body, bonnet and O-ring plate shall be fusion-bonded epoxy coated, both interior and exterior on body and bonnet. Epoxy shall be applied in accordance with AWWA C550 and be NSF 61 Certified.
 - 3) Wedge shall be ductile iron fully encapsulated in EPDM rubber.
 - 4) Hardware shall be 304 stainless steel
 - 5) Stems shall be cast copper alloy with integral collars in full compliance with AWWA. All stems shall operate with copper alloy stem nuts independent of wedge and of stem
 - 6) Provide standard AWWA 2-inch operating nut, matching valve key, and valve box for operating stem.
 - g. Manufacturers and Products:
 - 1) M&H/Kennedy Valve Company.
 - 2) Mueller.
 - 3) American.
 - 4) Crispin-Ludlow Valve.
- B. Self-Contained Automatic Valves:
1. Type V755: Clean Water Combination Air Valve, 1 Inch and Larger
- a. Valve shall be automatic float operated valve designed to exhaust large quantities of air during the filling of a piping system and close upon liquid entry. Valve shall open during draining or if negative pressures occur. Valve shall also release accumulated air from a piping system while system is in operation and under pressure.
 - b. Valve shall perform functions of both air release and Air/Vacuum valves and be furnished as a single body.
 - c. Valves used in potable water shall be NSF/ANSI certified.
 - d. Valve body and structure shall be constructed of cast iron or ductile iron. Float, guide shafts and bushings shall be stainless steel.
 - e. Manufacturers:
 - 1) Val-Matic.
 - 2) DeZurik.

3) Crispin Valve.

2.6 TAGGING REQUIREMENTS

- A. The tags shall be attached to the valves by soldered split key rings so that ring and tag cannot be removed. The tag shall bear the 1/4" die-stamped equipment identification number as indicated in the Contract Documents.

2.7 ACCESSORIES

- A. T-Handled Operating Wrench:
1. 2 each galvanized operating wrenches, 4 feet long.
 2. Manufacturers and Products:
 - a. Mueller; No. A-24610.
 - b. Clow No.; F-2520.
 3. 2 each galvanized operating keys for cross handled valves.
- B. Cast Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 6" ID shaft.
1. Box: Cast iron with minimum depth of 9".
 2. Lid: Cast iron, minimum depth 3", marked for the appropriate service.
 3. Extensions: Cast iron.

PART 3 - EXECUTION

3.1 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. Install a line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flow meters, for isolation during maintenance.
- D. Install safety isolation valves on compressed air.
- E. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.
- F. Extension Stem for Operator: Where the depth of the valve is such that its centerline is more than 3 feet below grade. Furnish an operating extension stem with 2" operating nut to bring the operating nut to a point 6" below the surface of the ground and/or box cover.
- G. 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 the valve.
- H. Floor Box and Stem: Steel extension stem length shall locate operating nut in floor box.

3.2 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 with operating pressure on one side and atmospheric pressure on the other, in both directions for two-way valve and applications.
- 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 any discrepancies with Manufacturer's data.
- E. Set, verify, and record set pressures for all relief and regulating valves.
- F. Automatic valve to be tested in conjunction with control system testing.
- G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.3 MANUFACTURER'S SERVICES

- A. A Manufacturer's representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services herein under, travel time excluded:
 - 1. 2 person-days for installation assistance, inspection, and certification of the installation. Provide certificate.
 - 2. 2 person-days for functional and performance testing.
 - 3. 2 person-days for pre-startup classroom or jobsite training of OWNER'S personnel.
- B. Training of OWNER'S personnel shall be at such times and at such locations as requested by OWNER.

3.4 MANUFACTURER'S CERTIFICATE(S)

- A. Provide Manufacturer's certificate(s).

END OF SECTION

SECTION 40 24 00 - PROCESS PIPING SPECIALTIES

PART 1 - GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American National Standards Institute (ANSI):
 - a. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
 - b. B16.5, Pipe Flanges and Flanged Fittings.
 2. American Society for Testing and Materials (ASTM):
 - a. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - b. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
 3. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.2 SUBMITTALS

- A. Shop Drawings: Manufacturer's data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide required piping specialty items, whether shown or not shown on the Drawings, as required by applicable codes and standard industry practice.
- B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded pipe joints are not.

2.2 CONNECTORS

- A. Teflon Bellows Connector:
1. Type: Two convolutions unless otherwise shown, with metal reinforcing bands.
 2. Flanges: Ductile iron, drilled 150 psi ANSI B16.5 standard.
 3. Working Pressure Rating: 140 psi, minimum, at 120 ° F.
 4. Thrust Restraint: Limit bolts to restrain the force developed by the specified test pressure.
 5. Manufacturers and Products:
 - a. Garlock; Style 214.
 - b. Resistoflex; No. R6904.
- B. Elastomer Bellows Connector:
1. Type: Fabricated spool, with single filled arch.
 2. Materials: Nitrile tube and neoprene cover.
 3. End Connections: Flanged, drilled 125-pound ANSI B16.1 standard, with full elastomer face and steel retaining rings.
 4. Working Pressure Rating: 140 psig, minimum, at 180° F for sizes 12" and smaller.
 5. Thrust Restraint: Control rods to limit travel of elongation and compression.
 6. Manufacturers and Products:
 - a. Goodall Rubber Co.; Specification E-1462.
 - b. Garlock; Style 204.
- C. Sleeve Type Coupling Manufacturers:

1. Dresser.
2. Rockwell.

D. Closure Collar Concrete: As specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

2.3 EXPANSION JOINTS

A. Elastomer Bellows:

1. Type: Reinforced, molded wide-arch.
2. End Connections: Flanged, drilled 125-pound ANSI B16.1 standard with split galvanized steel retaining rings.
3. Washers: Over the retaining rings to help provide a leak proof joint under test pressure.
4. Thrust Protection: Control rods to protect the bellows from overextension.
5. Bellows Arch Lining: Buna-N, nitrile, or butyl.
6. Rated Temperature: 250° F.
7. Rated Deflection and Pressure:
 - a. Lateral Deflection: 3/4" minimum.
 - b. Burst Pressure: Four times the working pressure.
 - c. Compression deflection and minimum working pressure as follows:

Size (inch)	Deflection (inch)	Pressure (psig)
2-1/2 to 12	1.06	150
14	1.65	130
16 to 20	1.65	110

8. Manufacturers and Products:
 - a. General Rubber Corp.; Style 1015 Maxijoint.
 - b. Mercer; Flexmore Style 450.
 - c. Goodall Rubber Co.; Specification E-711.

B. Teflon Bellows:

1. Type: Three convolutions, with metal reinforcing bands.
2. Flanges: Ductile iron, drilled 150 psi ANSI B 16.5 standard.
3. Working Pressure Rating: 100 psig, minimum, at 120° F.
4. Thrust Restraint: Limit bolts to restrain the force developed by the specified test pressure.
5. Manufacturers and Products:
 - a. Garlock; Style 215.
 - b. Resistoflex; No. R6905.

C. Copper Pipe Expansion Compensator:

1. Material: All bronze.
2. Working Pressure Rating: 125 psig, minimum.
3. Accessories: Anti-torque device to protect the bellows.
4. Manufacturers and Products:
 - a. Flexonics; Model HB.
 - b. Hyspan; Model 8509 or 8510.

D. Galvanized and Black Steel Pipe Expansion Compensator:

1. Material: Carbon steel with stainless steel bellows.
2. Working Pressure Rating: 150 psig, minimum.
3. Accessories: Anti-torque device to protect the bellows.
4. Manufacturers and Products:
 - a. Flexonics; Model H.
 - b. Hyspan; Model 8503.

- E. Flexible Metal Hose:
 1. Type: Close pitch, annular corrugated with single braided jacket.
 2. Material: Stainless steel, ASTM A276, Type 321.
 3. End Connections:
 - a. 3" and Larger: Shop fabricated flanged ends to match mating flanges.
 - b. 2-1/2" and Smaller: Screwed ends with one union end.
 4. Minimum Burst Pressure: 600 psig at 70° F for 12" and smaller.
 5. Length: Provide hose live-length equal to the lengths shown on the Drawings.
 6. Manufacturers and Products:
 - a. Flexonics; Series 401M.
 - b. Anaconda; BWC21-1.

2.4 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

- A. Manufacturers and Products:
 1. Flexonics; Model TCS, with tie bolts.
 2. Keflex; Type 152-TR, with tie bolts.

2.5 SERVICE SADDLES

- A. Double-Strap Iron:
 1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
 2. Run Diameter: Compatible with the outside diameter of the pipe on which the saddle is installed.
 3. Taps: Iron pipe threads.
 4. Materials:
 - a. Body: Malleable or ductile iron.
 - b. Straps: Galvanized steel.
 - c. Hex Nuts and Washers: Steel.
 - d. Seal: Rubber.
 5. Manufacturers and Products:
 - a. Smith-Blair; Series 313 or 366.
 - b. Dresser; Style 91.

- B. Nylon-Coated Iron:
 1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
 2. Run Diameter: Compatible with the outside diameter of the pipe on which the saddle is installed.
 3. Materials:
 - a. Body: Nylon-coated iron.
 - b. Seal: Buna-N.
 - c. Clamps and Nuts: Stainless steel.
 4. Manufacturer and Product:
 - a. Smith-Blair; Style 315 or 317.

2.6 INSULATING FLANGES, COUPLINGS, AND UNIONS

- A. Materials:
 1. In accordance with the applicable piping material specified in the Pipe Data Sheets.
 2. Galvanically compatible with piping.

- B. Union Type:
 1. 2" and Smaller: Screwed or solder-joint.
 2. 2-1/2" and Larger: Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.

- C. Working Pressure Rating: Suitable for specified system working pressure.
- D. Manufacturers and Products:
 - 1. Dielectric Flanges and Unions:
 - a. Epcos Sales, Inc.
 - b. Capitol Insulation Unions.
 - 2. Insulating Couplings:
 - a. Dresser; STAB-39.
 - b. R. H. Baker; Series 216.

2.7 WALL PIPES

- A. Ductile Iron Wall Pipe:
 - 1. For penetrations through concrete walls, floors, slabs, or roofs that are to be watertight.
 - 2. Diameter and Ends: Same as connecting ductile iron pipe.
 - 3. Thickness: Equal to or greater than remainder of pipe in line.
 - 4. Fittings: In accordance with applicable Pipe Data Sheet.
 - 5. Thrust Collars:
 - a. Provide for all wall pipes.
 - b. Rated for thrust load developed at 250 psi.
 - c. Safety Factor: 2, minimum.
 - d. Material and Construction:
 - Ductile iron or cast iron, cast integral with wall pipe wherever possible.
 - Fabricate welded attachment of ductile iron thrust collar to pipe where casting impossible. Perform in pipe manufacturer's shop by qualified welders. Electric arc welds of ductile iron with NI-55 or FC-55 nickel-iron-carbon weld rod. Continuously weld on each side all around.
 - 6. Manufacturers: American Cast Iron Pipe Co.; U.S. Pipe and Foundry Co.
 - 7. Coating After Fabrication: Prepare and coat wall pipe in accordance with and as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS, System No. 2
- B. Steel or Stainless Steel Wall Pipe:
 - 1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
 - 2. Lining: Same as connecting pipe.
 - 3. Thrust Collar: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe. Continuously fillet weld on each side all around.
 - 4. Coating After Fabrication: Prepare and coat wall pipe in accordance with and as specified in Section 09 90 00, PAINTING AND PROTECTIVE COATINGS, System No. 2
 - 5. Restraint: Provide lugs for use with thrust ties as specified.

2.8 PIPE SLEEVES

- A. Steel Pipe Sleeve:
 - 1. Material: 3/16" minimum thickness steel pipe.
 - 2. Seep Ring:
 - a. 3/16" minimum thickness center steel flange for water stoppage on sleeves in exterior or water-bearing walls.
 - b. Outside Diameter: 3" greater than pipe sleeve outside diameter.
 - c. Continuously fillet weld on each side all around.
 - 3. Factory Finish:
 - a. Galvanizing:
 - Hot-dip applied, meeting requirements of ASTM A153.
 - Electroplated zinc or cadmium plating is unacceptable.
 - b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, PROTECTIVE PAINTING AND COATINGS, System No.2.

- B. Insulated and Encased Pipe Sleeve:
 1. Manufacturer: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.
- C. Modular Mechanical Seal:
 1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
 2. Fabrication: Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts, nuts, and pressure plates.
 3. Size: According to Manufacturer's instructions for the size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40 feet of water.
 4. Manufacturer: Thunderline Link-Seal.

2.9 MISCELLANEOUS SPECIALTIES

- A. Strainers for Process Water Service, 2" and Smaller:
 1. Type: Bronze Body, Y-Pattern, 200 psi non-shock rated, with screwed gasketed bronze cap.
 2. Screen: Heavy gauge Type 304 stainless steel or Monel, 20-mesh
 3. Manufacturers:
 - a. Armstrong International, Inc.; Model F
 - b. Mueller Steam Specialty; Model 351M.
- B. Strainers for CPVC, Plastic Piping Systems, 4" and Smaller:
 1. Type: Y-pattern CPVC body, 150 psi non-shock rated, with screwed CPVC cap; and PTFE Teflon seals as recommended by manufacturer for service.
 2. End Connections: Screwed or solvent weld, 2" and smaller. Class 150 ANSI flanged, 1-1/2" and larger.
 3. Screen: Heavy-gauge CPVC, 1/32" mesh, minimum 2 to 1 screen area to pipe size ratio.
 4. Manufacturers and Products: Hayward; Series 85/80, or equal.
- C. Spray Nozzles:
 1. Scum Spray Nozzle Type 1:
 - a. Spray Pattern: Even
 - b. Spray Angle: 140° at 60 psi
 - c. Material: 316 Stainless Steel
 - d. Deflection Angle: 75°
 - e. Capacity: 8 gpm at 40 psi
 - f. Size: 1/2" NPT
 - g. Provide nozzle with adjustable ball fitting
 - h. Manufacturer and Produce: Spraying System Co., Nozzle Type K; or equal.
 2. Scum Spray Nozzle Type 2:
 - a. Spray Pattern: Solid narrow angle cone-shaped spray pattern with round impact area
 - b. Spray Angle: 15° at 40 psi
 - c. Material: 316 stainless steel
 - d. Capacity: 3 gpm at 40 psi
 - e. Size: 1/4" NPT
 - f. Provide nozzle with adjustable ball fitting
 - g. Manufacturer and Product: Spraying System Co., Nozzle Type G-15; or equal.
 3. Scum Spray Nozzle Type 3:
 - a. Spray Pattern: Deflected flat spray pattern at low pressure
 - b. Counterweight lever which when lifted, allows the solid stream flow to purge nozzle.
 - c. Material: Bronze with neoprene rubber deflector
 - d. Size: 1/4" NPT

- e. Manufacturer and Product: Spraying System Co., 22561 Foam Control Spray Nozzles; or equal.
- D. Quick Couplings:
- 1. Provide female NPT by male quick-connect hose adaptors. All adapters and couplers shall satisfy dimensional requirements of MIL-C-27487E and shall be cast iron and sized shown on the Drawings.
 - 2. Manufacturers and Products: Swagelock; Series QH.
- E. Quick Disconnect Cam Operating Couplings for Chemical Service:
- 1. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
 - 2. Material: Glass-filled polypropylene and PVDF with Teflon gaskets and as recommended for the service by Manufacturer.
 - 3. End Connections: NPT threaded or flanged to match piping connections.
 - 4. Hose shanks for chemical installations.
 - 5. Plugs and Caps: Female dust cap for each male end, male dust plug for each female end.
 - 6. Pressure Rating: 125 psi, minimum at 70° F.
 - 7. Manufacturers:
 - a. OPW; Kamlock
 - b. Ryan Herco; 1300 Series
 - c. Goodall; Basic Eight
- F. Chemical Injection Quills:
- 1. Retractable injection quill, service rated for 250 psi, including stainless steel check valve, ball valve, solution tube adaptor, packing nut, restraint system, and limit chains, and 300 Series O-ring gaskets.
 - 2. Manufacturer and Products: SAF-T-FLO; or equal.

PART 3 - EXECUTION

3.1 SHIPPING, STORAGE, HANDLING, AND PROTECTION

- A. Install process piping specialties in accordance with manufacturer's directions, as shown on the Drawings, and as specified herein.

3.2 PIPING FLEXIBILITY PROVISIONS

- A. General:
 - 1. Install thrust protection.
 - 2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.
- B. Flexible Joints at Concrete Backfill or Encasement: Install within 18" or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.
- C. Flexible Joints at Concrete Structures:
 - 1. Install 18" or less from the face of structures; joint may be flush with face.
 - 2. Install a second flexible joint, whether or not shown.
 - a. Pipe Diameter 18" and smaller: Within 18" of the first joint.
 - b. Pipe Diameter Larger than 18": Within one pipe diameter of the first joint.

3.3 PIPING TRANSITION

- A. Applications:
 - 1. Provide complete closure assembly where pipes meet other pipes or structures.

2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipes where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling Manufacturer's instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
 - a. Locate away from structures so that there are at least two flexible joints between the closure and pipe entering the structure.
 - b. Clean pipe surface before closure collars are placed.
 - c. Wet non-metallic pipe thoroughly prior to pouring collars.
 - d. Prevent concrete from entering pipe.
 - e. Extend collar a minimum of 12" on each side of joint with minimum thickness of 6" around outside diameter of pipe.
 - f. Make entire collar in one placement.
 - g. After concrete has reached initial set, cure by covering with well moistened earth.

3.4 PIPING EXPANSION

- A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.
- B. Expansion Joints:
 1. Grooved Joint and Flanged Piping Systems: Elastomer Bellows Expansion Joint.
 2. Nonmetallic Pipe: Teflon Bellows Expansion Joint.
 3. Screwed and Soldered Piping Systems: Copper or Galvanized and Black Steel Pipe Expansion Compensator, as applicable.
 4. Pipe Run Offset: Flexible Metal Hose.
- C. Anchors and Anchor Walls: Install to withstand expansion thrust loads and to direct and control thermal expansion.

3.5 SERVICE SADDLES AND THRUST TIES

- A. Service Saddles:
 1. Ferrous Metal Piping (except stainless steel): Double-strap iron.
 2. Plastic Piping: Nylon-coated iron.
- B. Thrust Ties:
 1. Install where shown and where required to restrain the force developed by the specified test pressure.
 2. Steel Pipe: Attach with fabricated lugs.
 3. Ductile Iron Pipe: Attach with socket clamps against a grooved joint coupling or flange.
 4. Flanged Coupling Adapters: For exposed installations, install Manufacturer's anchor studs through the coupling sleeve.
- C. Installation: Install in accordance with Manufacturer's written instructions.
 1. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
 2. Remove pipe coating if necessary to present smooth surface.

3.6 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

- A. Tie Bolts: Tighten snug prior to applying any pressure to the system.

3.7 INSULATING FLANGES, COUPLINGS, AND UNIONS

- A. Applications:
 - 1. Copper to ferrous metal piping connections.
 - 2. Cathodically protected piping penetration to buildings and watertight structures.
 - 3. Submerged to un-submerged metallic piping connections.
 - 4. Where required for electrically insulated connection.
- B. Installation of Insulating Kits: Drill oversize to accommodate insulating sleeves through the bolt holes, assuming standard bolt sizes.
- C. Pipe Installation:
 - 1. Insulating joints connecting immersed piping to non-immersed piping shall be installed above maximum water surface elevation.
 - 2. All submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete basins shall be isolated from the concrete reinforcement steel.

3.8 WALL PIPES

- A. Applications:
 - 1. As specified in Section 40 23 39, PROCESS PIPING - GENERAL
 - 2. Watertight and Below Ground Penetrations:
 - a. Wall pipes with thrust collars.
 - b. Provide taps for stud bolts in flanges to be set flush with wall face.
 - c. Existing Walls: Rotary drilled holes.
 - 3. Wall Pipe Installation:
 - a. Isolate embedded metallic piping from concrete reinforcement.
 - b. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

3.9 PIPE SLEEVES

- A. Application:
 - 1. As specified in Section 40 23 39, PROCESS PIPING - GENERAL.
 - 2. Above Grade in Non-submerged Areas: Hot-dip galvanized after fabrication.
 - 3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.
- B. Installation:
 - 1. Support non-insulating type securely in form work to prevent contact with reinforcing steel and tie-wires.
 - 2. Caulk joint with rubber sealant or seal with wall penetration seal.

3.10 MISCELLANEOUS SPECIALTIES

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

END OF SECTION

DIVISION 43
PROCESS LIQUID HANDLING

SECTION 43 41 17 – STEEL HYDROPNEUMATIC PRESSURE TANKS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section includes the Work necessary to furnish and install complete, the Steel Hydropneumatic Pressure Tanks including all related equipment, material, and appurtenances.

1.2 GENERAL

- A. Equipment Numbers: PT01 and PT02.
- B. Like items of equipment provided hereinafter shall be the end products of one Manufacturer to achieve standardization of appearance, operation, maintenance, spare parts, and Manufacturer's services.
- C. Unit Responsibility: The Work requires that the steel tanks, complete with all accessories and appurtenances, be the end product of one responsible Manufacturer. The Manufacturer shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features and functions without altering or modifying the Contractor's responsibilities under the Contract Documents. The Contractor is responsible to the Owner for providing the systems as specified herein.
- D. See Division 01, GENERAL REQUIREMENTS, which contains information and requirements that apply to the work specified herein and are mandatory for this project.

1.3 DESIGN REQUIREMENTS

- A. The hydropneumatic tank must be constructed in accordance with most recent addendum of Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code.
- B. The hydropneumatic tank facility must be constructed in accordance with the Texas Commission on Environmental Quality (TCEQ) Rules and Regulations for Public Water Systems 30 Texas Administrative Code (TAC) Chapter 290 Subchapter D. When conflicts are noted with local standards, the more stringent requirement shall be applied. At a minimum, construction for public water systems must always meet TCEQ's "Rules and Regulations for Public Water Systems."
- C. All hydropneumatic tanks must be located wholly above grade and must be of steel construction with welded seams.
- D. Metal thickness for pressure tanks shall be sufficient to withstand the highest expected working pressures with a four to one factor of safety. Tanks for 1000 gallon capacity or larger must meet the standards of the American Society of Mechanical Engineers (ASME) Section VIII, Division 1 Codes and Construction Regulations and must have an access port of periodic inspections. An ASME name plate must be permanently attached to those tanks. Tanks installed before July 1, 1988, are exempt from the ASME coding requirement, but all new installations must meet this regulation. Exempt tanks can be relocated within a system, but cannot be relocated to another system.
- E. All pressure tanks shall be provided with an air fill valve connection (0.302"-32), replaceable bladder, pressure release device, isolation valve, and an easily readable pressure gauge.

- F. Facilities shall be provided for maintaining the air-water-volume at the design water level and working pressure. Air injection lines must be equipped with filters or other devices to prevent compressor lubricant and other contaminants from entering the pressure tank. A device to readily determine air-water-volume must be provided for all tanks greater than 1000 gallon capacity. Galvanized tanks which are not provided with the necessary fittings and were installed before July 1, 1988, shall be exempt from this requirement.
 - G. Hydropneumatic pressure tanks shall be painted, disinfected and maintained in strict accordance with current American Water Works Association (AWWA) standard. Protective paint or coating shall be applied to the inside portion of any pressure tank. However, no temporary coating, wax, grease coating or coating materials containing lead will be allowed. No other coating will be allowed which are not approved for use (as a contact surface with potable water by the United States Environmental Protection Agency (EPA), NSF International, The United States Food and Drug Administration (FDA). All newly installed coatings must conform to ANSI/NSF International Standard 61 and must be certified by an organization accredited by ANSI.
 - H. No pressure tank that has been used to store any material other than potable water may be used in a public water system. A letter from the previous owner or owners must be provided.
 - I. Pressure tank installations should be equipped with slow closing valves and time delay pump controls to eliminate water hammer to reduce the chance of tank failure.
 - J. Associated appurtenances including valves pipes and fittings connected to pressure tanks must conform to ANSI/NSF International Standard 61 and shall be thoroughly tight against leakage. Pursuant to 30 TAC §290.44(b)(1), the maximum allowable lead content of pipes, pipe fittings, plumbing fittings, and fixtures is 0.25 percent.
 - K. All tanks are to be cylindrical in shape, have domed ends, and be mounted vertically on a manufacturer designed base. The base is to be secured to the concrete pad according to manufacturer designed concrete anchors.
 - L. Lift rings are to be designed and adequately located according to the manufacturer.
 - M. The distribution system connection shall be located on the bottom of the tank and contain a valve to isolate the tank.
 - N. Disinfection of water storage facilities shall be in strict accordance with current AWWA Standard C652-11 or most recent.
 - O. Dechlorination of disinfecting water shall be in strict accordance with current AWWA Standard C655-09 or most recent.
 - P. No more than three pressure tanks shall be installed at any one site without the prior approval of the executive director.
 - Q. All potable water storage tanks and pressure maintenance facilities must be enclosed by an intruder resistant fence with lockable gates. Pedestal type elevated storage tanks with lockable doors and without external ladders are exempt from this requirement. The gates and doors must be kept locked whenever the facility is unattended.
- 1.4 SUBMITTALS
- A. Provide submittal for approval as specified in Section 8.3, SUBMITTALS of Uniform General Conditions for State of Texas Construction Contracts. The following specific information shall be provided:

1. Shop Drawings:
 - a. Complete Manufacturer's descriptive information and shop drawings for all equipment, materials, detailed fabrication drawings, and devices furnished.
 - b. Catalog information and cuts for all manufactured items, highlighted to show actual items and materials proposed to be provided.
 - c. Tank data indicating equipment number, pressure rating, bladder material, diameter, overall lengths, wall thickness, and details of nozzle designs.
 - d. All dimensions and locations of all major elements of the steel tanks and their accessories, critical clearance requirements, and support dimension requirements.
 - e. Installation or placing drawings for equipment, and installation requirements including location of anchors, and piping connections.
 - f. Layout and installation requirements of tank insulation.
 - g. Submit results of tests.
 - h. Tank capacity chart indicating gallons for each inch of depth and cumulative total from bottom.
 - i. Manufacturer's detailed requirements for anchor bolts.
2. Quality Control Submittals:
 - a. Fabricator's Certificate of Compliance with fabrication requirements.
 - b. Qualifications of fabricator's Quality Assurance Supervisor.
 - c. Copy of the fabricator's Quality Assurance Program.
 - d. Quality Assurance Inspection:
 - 1). Initial QA Inspection Report.
 - 2). Certification of Factory Testing.
 - e. Special shipping, storage and protection, and handling instructions.
 - f. Manufacturer's printed installation and tank support instructions.
 - g. Manufacturer's Certificate of Proper Installation.
 - h. Drawings and other information required in Part 1.3 DESIGN REQUIREMENTS of this Section.
 - i. Suggested spare parts list to maintain the equipment in service a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
 - j. List of special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.

1.5 OPERATION AND MAINTENANCE DATA

- A. Operation and maintenance manuals shall be provided in two copies to the Owner.
- B. Operation and maintenance manuals shall have been prepared for this specific project, and shall not be a general manual applicable to many systems. Manufacturers' technical manuals shall be included for each piece of equipment that is field serviceable.
- C. Manuals shall include the following:
- D. The approved submittal and shall be produced in the same format as the submittal, bound in a three ring binder, and tabbed.
- E. Manufacturer's manuals shall be included after the submittal pages for each field serviceable device
- F. Functional description of each major component, complete with operating instructions
- G. Instructions for operating pressure tank.

- H. Calibration and adjustment of equipment for initial start-up, replacement of control components, or as required for routine maintenance
- I. Support data for commercially available components not produced by the tank manufacturer, but supplied in accordance with the specifications, shall be supported by literature from the prime manufacturer and incorporated as appendices
- J. Mechanical layout drawing of the pump station and components, prepared in accordance with good commercial practice, shall provide installation dimensions and location of all pumps, motors, valves, piping and tanks.

1.6 QUALITY ASSURANCE

- A. Fabricator's Qualifications: Provide an independent certified Quality Assurance Supervisor of minimum 10 years experience in design and manufacture of similar tanks.
 - 1. Provide certificate of experience.
 - 2. Provide 5 project names – including owner, address, contact person, telephone number – for tanks designed and manufactured by fabricator that have been in service for more than 5 years.
- B. Fabricator's Quality Assurance Supervisor:
 - 1. Minimum 5 years experience as an hydropneumatic tank inspector.
 - 2. Representing a corporately and financially independent organization which can function as unbiased inspection authority.
 - 3. Professionally independent of Manufacturer's, suppliers, and installers of systems being inspected.
- C. Designer: Registered Professional Engineer.

1.7 WARRANTY

- A. Provide warranty for a period of 12 months after the final acceptance of the equipment by the Owner and Engineer. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer will promptly repair or replace the defective equipment without additional cost to the Owner.
- B. Spare parts identified within this specification shall not be used to address warranty repairs.

1.8 SEQUENCING AND SCHEDULING

- A. Tanks/Vessels shall not be shipped from factory until Engineer's review of Certification of Factory Testing is completed.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Some specific requirements relative to this section are attached as supplements at the end of the section.

2.2 MANUFACTURERS

- A. Where Manufacturer’s standard equipment name and/or model number is listed, the equipment system shall be provided as modified to conform to the performance, functions, features, and materials of construction as specified herein.
- B. Materials, equipment, components, and accessories specified in this Section shall be products of:
 - 1. FXA-800L. Wessels Company Greenwood, IN.
 - 2. Or equal.

2.3 SERVICE CONDITIONS

- A. Seismic Zone: See Section 01 81 02 SEISMIC DESIGN CRITERIA of these specifications.
- B. Normal Operating Pressure: 53 psi thru 43 psi.
- C. Quantity: Two (2)
- D. Volume: 200 gallons, minimum. (400 gallons combined, minimum)
- E. Connection: NPT epoxy lined system connections.
- F. The tank shall be installed with a pre-charge pressure equal to the system set point, 43 psi.

2.4 MATERIALS

- A. Tank: Carbon Steel
- B. Heads: Carbon Steel
- C. Exterior Tank Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
Abrasive Blast (SP 10)	Primer – Per Manufacturer’s Recommendations	1 coat, 2.5 MDFT
	Top Coat – Aliphatic Polyurethane	1 coat, 3 MDFT

- 1. Aliphatic or aliphatic-acrylic polyurethane: As manufactured by one of the following or equal:
 - a. Carboline: Carbothane 134 VOC.
 - b. Devoe: Devthane 379.
 - c. PPG Amercoat: Amershield VOC.
 - d. S-W: High Solids Polyurethane [CA].
 - e. Tnemec: Endura-Shield II Series 1075 (U).
- D. Bladder: Heavy duty butyl. NSF-61 listed and FDA approved.

2.5 APPURTENANCES

A. Supports:

1. Provide lifting lugs suitably attached for all tanks weighing over 100 pounds.
2. Anchor Bolts: Type 316, stainless steel bolts, sized by fabricator and at least 1/2" in diameter, or as shown and as specified in Section 05 50 00, METAL FABRICATIONS.
3. Anchor Bolt Clips: Provide minimum of four equally spaced anchor bolt clips on each tank. The anchor bolt clips to be fabricated from FRP or TYPE 316 stainless steel.
4. Safety Devices: The completed work shall include all necessary permanent safety devices, required by OSHA, and other Federal, State, and local health and safety regulations.

PART 3 - EXECUTION

3.1 GENERAL

- A. The equipment specified herein shall be located as shown on the Drawings and installed in conformance with the Manufacturer's suggested method as approved. The tanks shall be adequately protected as work is accomplished around the tanks.

3.2 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Deliver equipment to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- B. Where tank foundations are cutout to accommodate full bottom drains, after tank installation the cutout area shall be backfilled with grout or other material that will provide localized support.

3.3 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each tank.
2. Hydrostatic leak test with the tank full of clean water. Allow water to stand for 24 hours to verify no water leakage or pressure loss.

3.4 MANUFACTURER'S SERVICES

- A. A Manufacturer's representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services herein under, travel time excluded:
1. (2) person-days for installation assistance, inspection, and certification of the installation. Provide certificate.
 2. (1) person-day for pre-startup classroom or jobsite training of Owner's personnel.
- B. Training of Owner's personnel shall be at such times and at such locations as requested by Owner.

END OF SECTION

SECTION 43 42 56.31 – POTABLE WATER PUMP STATION SYSTEM

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. This specification section covers the labor and materials necessary to furnish and install a factory built complete, operable duplex booster pump station (BPS) for the potable water pump system to be utilized for pumping potable water into the natural area's water system. System to include all necessary pumps, piping, valves, instrumentation, pump controls, appurtenances, skid properties, and mounting as shown in the plans and specified herein.
- B. Pump system components shall be of the same manufacturer or supplier to obtain standardization of performance, operation, spare parts, maintenance, and manufacturer's services.
- C. Contractor shall furnish and install pump station. The station shall be complete with all equipment specified herein, factory assembled on a common steel base.
- D. All wetted material in contact with potable water supply shall be certified to NSF 61.

1.2 SUBMITTALS

- A. Submittals shall be made as required for all equipment. The following specific information shall be provided:
 - 1. Shop Drawings: Shop drawings shall include descriptive information as required to fully describe the Pumps, Piping, Valves, Motors, Control Panels, Instrumentation, and overall performance and shall identify any deviations from the specified requirements.
 - 2. Requirements for routine maintenance required prior to startup.
 - 3. List of all requested exceptions to the Contract Documents.
 - 4. Motor information to be submitted in accordance with Division 26, ELECTRICAL.
 - 5. Quality control submittals.
 - 6. Process and instrumentation diagram depicting the process equipment and instrumentation control devices for the operation of the booster pump station.
 - 7. Instrumentation and control submittals as listed in Section 26 90 00, GENERAL INSTRUMENTATION AND CONTROL.
 - 8. Factory Test Reports (Balance & Vibration).
- B. Provide submittal for approval as specified in Section 8.3, SUBMITTALS of Uniform General Conditions for State of Texas Construction Contracts the including no less than the following:
 - 1. Full set of mechanical drawings including skid framing and anchor bolt locations for station, connection dimensions, and equipment layout, all to scale
 - 2. Full electrical schematic, including three line power schematic, ladder logic, SCADA system interface. The electrical ladder logic drawings shall illustrate motor branch and control circuits to extent necessary to validate function and integration of circuits to form a complete working system
 - 3. Properly indicated pump curves, whose total dynamic head includes pumping system internal losses, manufacturer's name (other than pumping system manufacturer), pump model number, and motor type, RPM and horsepower
 - 4. Properly marked cut sheets for each major component of the pumping system, both mechanical and electrical
 - 5. Copies of UL and ETL authorizations for control panels, and for complete pumping system.

6. Complete description of the system including operation sequence, alarm sequence, SCADA interface (if required), receiving instructions, storage instructions and warranty statement
- C. Quality Control Submittals:
 - a. Manufacturer's Certificate of Compliance: Commercial products, including painting/coating systems.
 - b. Special shipping, storage and protection, and handling instructions.
 - c. Test results, reports, and certifications.
 - d. Manufacturer's Certificate of Proper Installation.
 - D. Contract Closeout Submittals: Service records for maintenance performed during construction.

1.3 OPERATION AND MAINTENANCE SUBMITTALS

- A. Operations and Maintenance Data: Submit data on all parts, devices, equipment, and other accessories furnished forming the complete operational system. Specifically include:
 1. Equipment function, normal operating characteristics, and limiting conditions.
 2. Assembly, installation, alignment, adjustment, and checking instructions.
 3. Operating instructions for start-up, routine and normal operation, regulation and control, shutdown and emergency conditions.
 4. Lubrication and maintenance instructions.
 5. Guide to "troubleshooting."
 6. Parts lists and predicted life of parts subject to wear.
 7. Outline, cross section, and assembly drawings; engineering data; and wiring diagrams.
 8. Data and performance curves.
 9. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1.4 MANUFACTURER

- A. The pumping system shall be, as manufactured by Tigerflow, Dallas, Texas, or equal.
- B. In event the contractor submits equipment for substitution, the contractor shall, at his own expense, make all resulting changes to the enclosure, piping or electrical systems as required to accommodate the proposed equipment. Revised detail drawings illustrating the substituted equipment shall be submitted to the engineer prior to acceptance. If the cost to the contractor is less for the proposed substitution, then the contract price shall be reduced by an amount equal to the savings.

1.5 DELIVERY, STORAGE, HANDLING

- A. Equipment shall be delivered to the jobsite completely factory.
- B. Electrical motors and components shall be kept thoroughly dry at all times and shall be stored indoors. Equipment storage shall be protected and maintained in accordance with the manufacturer's recommendations. Equipment shall not be stored directly on the ground.
- C. Contractor shall utilize equipment and tools of adequate size suitable for unloading, transporting, storing and supporting the equipment during installation. Caution shall be employed to prevent equipment damage resulting from abrupt contact with other materials or equipment.

1.6 QUALITY ASSURANCE

- A. In order to unify responsibility for proper operation of the complete pumping station, it is the intent of these Specifications that all system components be furnished by a single supplier (unitary source). The pumping station must be of standard catalog design, totally warranted by the manufacturer. Under no circumstances will a system consisting of parts compiled and assembled by a manufacturer's representative or distributor be accepted
- B. Pumps shall be as specified in Part 2.3 of this specification.
- C. Upon request from the engineer, the pump station manufacturer shall prove financial stability and ability to produce the station within the specified delivery schedules. Evidence of facilities, equipment and expertise shall demonstrate the manufacturer's commitment to long term customer service and product support.
- D. The term "pump manufacturer" or "pump station manufacturer" shall be defined as the entity which designs, machines, assembles, hydraulically tests and warranties the final product. Any entity that does not meet this definition will not be considered a "pump manufacturer" or "pump station manufacturer" and is not an acceptable supplier. For quality control reasons and future pump and parts availability, all major castings of the pump shall be sourced and machined in North America.
- E. The pump manufacturer shall submit to the contractor for Engineer's review, certified copies of factory hydraulic pump test results for each pump. Test results shall be submitted prior to shipment upon Engineer's request and shall show compliance with specified performance requirements.

1.7 WARRANTY

- A. The pump station manufacturer shall warrant all equipment to be of quality construction, free of defects in material and workmanship. A written warranty shall include specific details described below to be provided after the final acceptance of the equipment by the Owner and Engineer. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer will promptly repair or replace the defective equipment without additional cost to the Owner.
- B. All other equipment, apparatus, and parts furnished shall be warranted for sixty (60) months, excepting only those items that are normally consumed in service, such as light bulbs, oils, grease, packing, gaskets, O rings, etc. The pump station manufacturer shall be solely responsible for warranty of the station and all components.
- C. Upon request from the Engineer and/or the owner, the manufacturer shall demonstrate proof of financial responsibility with respect to performance and delivery date. In addition, the manufacturer shall provide proof of evidence of facilities, equipment, and skills required to produce the equipment specified herein and provide technical service and replacement parts.
- D. Components failing to perform as specified by the engineer, or as represented by the manufacturer, or proven defective in service during the warranty period, shall be replaced, repaired, or satisfactorily modified by the manufacturer without cost of parts or labor to the owner.
- E. It is not intended the manufacturer assume liability for consequential damages or contingent liabilities arising out of failure of any product or parts thereof to operate properly, however caused

by or resulting from or arising out of defects in design or manufacture, delays in delivery, replacement, or otherwise.

1.8 FACTORY TEST

- A. All components including the pumps, motors, valves, piping, instrumentation, and controls will be tested as a complete working system at the manufacturer's facility. Tests shall be conducted in accordance with Hydraulic Institute Standards at the specified head, capacity, rated speed and horsepower. Factory operational test shall duplicate actual performance anticipated for the complete station.
- B. Motor, commercial tests shall be made, including no-load current at rated voltage, high potential, and locked rotor current.
- C. Certified copies of test reports on actual pumps and motors being supplied shall be provided to Engineer for review.
- D. Upon request from the engineer, the operational test may be witnessed by the engineer, and/or representatives of his choice, at the manufacturer's facility.

1.9 OPERATION AND MAINTENANCE

- A. Operation and maintenance manuals shall be provided in two copies to the Owner.
- B. Operation and maintenance manuals shall have been prepared for this specific project, and shall not be a general manual applicable to many systems. Manufacturers' technical manuals shall be included for each piece of equipment that is field serviceable.
- C. Manuals shall include the following:
 - 1. The approved submittal and shall be produced in the same format as the submittal, bound in a three ring binder, and tabbed.
 - 2. Manufacturer's manuals shall be included after the submittal pages for each field serviceable device
 - 3. Functional description of each major component, complete with operating instructions
 - 4. Instructions for operating pumps and pump controls in all modes of operation.
 - 5. Calibration and adjustment of equipment for initial start-up, replacement of control components, or as required for routine maintenance
 - 6. Support data for commercially available components not produced by the station manufacturer, but supplied in accordance with the specifications, shall be supported by literature from the prime manufacturer and incorporated as appendices
 - 7. Electrical schematic diagram of the pump station circuits shall be in accordance with NMTBA and JIC standards. Schematics shall illustrate, to the extent of authorized repair, pump motor branch, control and alarm system circuits including interconnections. Wire numbers and legend symbols shall be shown. Schematic diagrams for individual components, not normally repairable by the station operator, need not be included. Details for such parts shall not be substituted for an overall system schematic. Partial schematics, block diagrams, and simplified schematics shall not be provided in lieu of an overall system diagram.
 - 8. Mechanical layout drawing of the pump station and components, prepared in accordance with good commercial practice, shall provide installation dimensions and location of all pumps, motors, valves and piping.

1.10 CODES

- A. Without exception, pumping system shall be UL and ETL listed as finally assembled.
- B. Control panel with controls shall be built in accordance to NEC, and U.L and ETL standards.
- C. Without exception, the electrical components and enclosure shall be labeled as a complete U.L. and ETL listed industrial control panel assembly.
- D. Manufacturer's U.L. and ETL labels shall be applied to the door.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Equipment Numbers: BP01 and BP02.
- B. Unit Responsibility: The Work requires that the pump, electric motor, base frame, coupling, and coupling guard with all accessories and appurtenances be the end product of one responsible system manufacturer or responsible system supplier. Unless otherwise indicated, the Contractor shall obtain each system from the responsible supplier of the equipment, which supplier shall furnish all components and accessories of the system to enhance compatibility, ease of operation and maintenance, and as necessary to place the equipment in operation in conformance with the specified performance, features, and functions without altering or modifying the Contractor's responsibilities under the Contract Documents. The Contractor is responsible to the Owner for providing the equipment systems as specified herein.
 - 1. The packaged pump station's suction and discharge piping shall be connected to the distribution piping and hydropneumatic tanks piping using 4" flanged connections. These connections shall be made inside of the pump station enclosure. There shall be a connection between the discharge and suction lines and it shall contain a check valve. This check valve shall allow the BPS to be bypassed in the event that the BPS pumps can no longer provide a pressure greater than what is provided by the existing ground storage tank. See part 2.5 of this specification for piping specifications.
- C. Warranty
 - 1. Provide warranty for a period of 36 months after the final acceptance of the equipment by the Owner and Engineer. The warranty shall stipulate that the equipment furnished is suitable for the purpose intended and free from defects of material and workmanship for the duration of the warranty. In the event the equipment fails to perform as specified, the Manufacturer shall promptly repair or replace the defective equipment without additional cost to the Owner.
 - 2. Spare parts identified within this specification shall not be used to address warranty repairs.
- D. Electrical: 240V/1ph/60hz

2.2 UNIT BASE

- A. The pad for the pump station shall be a reinforced concrete pad that meets the specifications of the manufacturer. The pad shall be a minimum of 8 inches thick and be placed on a 1 foot thick layer of flexible base course in accordance with Section 32 11 00. All concrete shall conform to SPECIFICATION SECTION 03 00 00 CONCRETE.

- B. The unit base shall comprise a base plate, perimeter flange, and reinforcements. Base plate shall be fabricated of steel not less than 1/4" thick. Perimeter flange and reinforcements shall be designed to prevent flexing or warping under operating conditions. Base plate and/or flange shall be drilled for hardware used to secure unit base to concrete pad as shown on the contract drawings. Unit base shall contain provisions for lifting the complete pump unit during shipping and installation

2.3 PUMPS

- A. Vertical multistage, type equal in construction and performance to the VMS-4000 Series, size CD 10-3, mechanical seal, stainless steel; as manufactured by the Tiger Flow, or equal.
- B. All pump bearings shall be lubricated by the pumped liquid.
- C. Each pump shall be designed for in-line installation requiring no more than 1.0 square feet of floor space, including motor.
- D. The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.
- E. The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as indicated in the drawings or pump schedule.
- F. Pump Construction
 - 1. The suction/discharge base, pump head, and motor stool shall be Class 30 cast iron.
 - 2. The impellers, diffuser chambers, and outer sleeve shall be type 304 stainless steel.
 - 3. The shaft shall be type 316 or 431 stainless steel.
 - 4. The impeller wear rings shall be type 304 stainless steel.
 - 5. The shaft journals and chamber bearings shall be silicon carbide.
 - 6. The O-rings shall be of EPDM material.
- G. Shaft couplings for motor flange sizes 184TC and smaller shall be made of cast iron or sintered steel. Shaft couplings for motor flange sizes larger than 184TC shall be made of ductile iron.
- H. Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel resulting in all wetted parts of stainless steel.
- I. The shaft seal shall be a balanced o-ring cartridge type with the following features:
 - 1. The collar, drivers, and spring shall be type 316 stainless steel.
 - 2. The shaft sleeve and gland plate shall be type 316 stainless steel.
 - 3. The stationary ring and rotating ring shall be silicon carbide.
 - 4. The O-rings shall be of EPDM material.
- J. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling, and motor. Pumps with motors equal to or larger than 15 HP shall have adequate space within the motor stool so that shaft replacement is possible without motor removal.
- K. The maximum working temperature shall be 250 degrees F. The maximum working pressures are as follows:
 - 1. For a 1" or 1 1/4" Internal Thread (NPT) connection, the maximum working pressure is 232 psig.
 - 2. For a 2" Internal Thread (NPT) connection, the maximum working pressure is 145 psig.
 - 3. For ANSI Flange (Class 250) connections, the maximum working pressure is 362 psig.

L. Motors

1. Motors are to be provided with the following basic features:
 - 1) Motors shall be 240V/1ph/60hz designed for continuous duty operation, NEMA design B with a 1.15 safety factor.
 - 2) Totally Enclosed Fan Cooled motors are to be furnished with class F insulation.
 - 3) Motor nameplate shall be mounted on enclosure with stainless steel fastening pins. Nameplate shall have, as a minimum, all information as described in NEMA Standard MG 1-20.40.1.
 - 4) Motors over 50 pounds shall have lifting provisions.
 - 5) Motors shall have a NEMA C-flange for vertical mounting.
 - 6) Drive end bearings shall be adequately sized so that the minimum L-10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump.
 - 7) 240V.

M. Pump Schedule

1. Quantity: (2) Vertical In-Line Multistage Centrifugal Pumps
2. Pump Design Flow and TDH: 40 gpm @ 111' TDH.
3. Minimum Efficiency at Design Flow: 65%
4. Liquid Pumped: Potable Water
5. Liquid Temperature: 40 – 70 deg F

2.4 VALVES AND APPURTENANCES

- A. Combination pressure regulating and check valves shall be Singer 106-PR-C angle pattern, epoxy coated, and NSF 61 certified.
- B. Pump station bypass valve shall be Type V608 and meet the specifications below:
- C. Type V608: Swing Check Valve, 2 Inches and Larger
 - a. AWWA C508, flanged end, cast iron body, bronze mounted valve, solid bronze hinges, stainless steel hinge shaft.
 - b. Valve 2" through 12" rated 175-pound and 14" through 36" rated 150-pound cold water, non-shock. Valve fitted with adjustable outside lever and spring. Increasing-pattern body valve may be used where increased outlet piping size is shown.
 - c. Manufacturers:
 - 1) Crispin Valve
 - 2) Val-Matic
 - 3) DeZurik.
 - 4) Or approved equal.
- D. Equipment isolation valves shall be Type V500 and meet the specifications below:
- E. Type V500: Butterfly Valve, 4 Inches and Larger
 - a. General: Provide valves designed and manufactured in accordance with AWWA C504. NSF-61 Certified.
 - b. Valve Style: Flanged end, short body type.
 - c. Flanged end connections shall fully conform with ANSI B16.1 Class 125.
 - d. Materials:
 - 1) Body: Class 150B valve bodies shall be ASTM A126, Class B gray iron or ASTM A536 Grade 65-45-12 ductile iron.
 - 2) Disc: Valve disc shall be made from cast iron ASTM A-126 Class B or stainless steel ASTM A351 in sizes 20" and smaller. Disc shall be furnished with Type 316 stainless steel seating edge to mate with the rubber seat on the body.

- 3) Shafts: Shafts shall be Stainless Steel. ASTM A276 Type 304, or Type 316, or ASTM A564, grade 630.
 - 4) Seat: Valve seat shall be Buna-N rubber located on the valve body. In sizes 20" and smaller, valves shall have bonded seats that meet test procedures outlined in ASTM D-429 Method B.
 - 5) Bearings: Shall be sleeve type that is corrosion resistant and self-lubricating.
 - 6) Manual Actuators: Shall be fully grease packed and have stops in the open/close position. The actuator shall have a mechanical stop which will withstand an input torque of 450 ft. lbs. against the stop. The traveling nut shall engage alignment grooves in the housing. The actuators shall have a built in packing leak bypass to eliminate possible packing leakage into the actuator housing.
 - 7) Hardware: All seat retaining hardware shall be Type 316 stainless steel.
- e. Manufacturers and Products:
- 1) Henry Pratt /Mueller
 - 2) DeZurik - AWWA Butterfly Valves (BAW) 150B
 - 3) Crispin Valve
 - 4) Val-Matic – American BFV 150B
 - 5) Or approved equal.

F. Suction Strainer

1. A strainer shall be installed on the suction of the piping. This strainer shall be able to remove objects greater than 6 mm in diameter to prevent damage to the pumps or piping.

G. Dismantling Joints:

1. Manufacturers and Products:
 - a. Steel or Ductile Iron Pipe:
 - 1) Smith-Blair; Series 975.
 - 2) Dresser Industries, Inc.; Style 131.
 - 3) Romac DJ400.
 - 4) Or approved equal.

H. Restrained Flanged Coupling Adapters:

1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1) Smith-Blair; Series 911.
 - 2) Romac RFCA.
 - 3) Or approved equal.
 - b. PVC Pipe:
 - 1) Smith-Blair; Series 920.
 - 2) Romac RFCA-PVC.
 - 3) Or approved equal.

2.5 PIPING

- A. All interior potable water package booster pump station piping shall be stainless steel, minimum of 3 in. diameter, and as specified below:

B. Fittings:

1. 2-1/2" and larger Butt Welded: ASTM A774/A774M-94 Grade 316L conforming to MSS SP-43, "as-welded" grade, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise.
2. Flanges are required for connection to the pump station valves. Flanges shall be Forged Stainless Steel, ASTM A182/A182M Rev C-93, and Grade F316L, ANSI B16.5-88 Class 150 or Class 300 slip-on weld neck or raised face

3. Type 316 stainless steel, ASTM A320/A320M-94 Grade B8M hex head bolts and ASTM A194/A194M-94 Grade 8M hex head nuts.
 4. Bolt holes shall be in angular alignment within 1/2 degrees between flanges. Flanges shall be faced with a gasket finish having concentric grooves a minimum of 0.01 inch deep by approximately 0.03 inch wide, with a minimum of three grooves on any given surface spaced a maximum of 1/4 inch apart.
 5. Gaskets: 1/8-inch thick, unless otherwise specified, homogenous black rubber (EPDM), hardness 60 (Shore A), rated to 212 degrees F., conforming to ANSI B16.21 and ASTM D1330 Steam Grade.
 6. Cast iron flanges shall be painted as specified in section 2.12. All piping shall be fusion bonded epoxy coated internally and externally to NSF 61 standards.
- C. All water package booster pump station piping shall be stainless steel, and as specified in Part 2.5. The stainless steel pipe and buried PVC pipe shall be connected as shown on the Drawings.

2.6 PIPING SUPPORT

- A. All piping supports shall cover 120 degrees of arc under the piping and support the weight of the piping and the water it contains.
- B. Piping support shall be welded to the skid and shall be bolted to tabs which are welded to the piping.
- C. Piping supports not supporting at least 120 degrees of arc under the piping shall not be accepted.
- D. Thrust shall be resisted through the use of a fabricated steel thrust block.
 1. Fabricated steel thrust block may be manufactured from two pieces of ASTM A36 plate bolted together. One piece of plate shall be welded along the axis of the pipe and the other to either the skid or the lower level piping, as required.
 2. In the event that the fabricated steel thrust block manufactured from two pieces of plate is deemed inadequate for any reason by the pumping system manufacturer, the fabricated steel thrust block may be manufactured from ASTM A36 structural steel shapes.
 3. Pumping system manufacturer shall have on staff a Professional Engineer responsible for thrust calculations and design of the thrust block.
 4. Provision of pumping system thrust blocks by the pumping system manufacturer does not relieve the installing contractor from properly thrust blocking his pipe so as to transmit no thrust to the pumping system.

2.7 PRESSURE GAUGES

- A. Ashcroft Duragauge Model 1279/1379 or equal.
- B. Pressure Connection: Internal 1/2" NPT thread.
- C. Wetted Material: Brass.
- D. Mounting: See Drawings for location.
- E. Application: Booster Pump Station Discharge Pressure, PI01
- F. Range: 0-75 psi.

2.8 PRESSURE SWITCHES

- A. Ashcroft or equal.
- B. Pressure Connection: Internal ½" NPT thread.
- C. Compatibility: Water.
- D. Power Supply: 120VAC.
- E. Enclosure: NEMA 4X.
- F. Setpoint/Contact:
 - 1. PS01: 48 psi/N.O.
 - 2. PS02: 43 psi/N.O.
 - 3. PS03: 53 psi/N.C.
 - 4. PS04: 35 psi/N.C.
 - 5. PS05: 60 psi/N.C.
- G. Range: 0-75 psi.

2.9 PUMP ALTERNATOR RELAY

- A. Macromatic Duplex DPDT Cross Wired Relay or equal.
- B. Power Supply: 120V
- C. LED Relay Status Indicators
- D. Rating: 10A
- E. Plug-in Mounting

2.10 PAINT

- A. Structural steel and supports shall be deslagged then grit-blasted per SSPC-SP6 to commercial blast condition.
- B. The cleaned steel surface shall be immediately coated with an aliphatic polyurethane coating to a thickness of no less than 5 mils and applied through an electrostatic method to insure proper adhesion.
- C. This aliphatic polyurethane coating shall meet or exceed the following testing criteria:
 - 1. Direct impact resistance of 140 in/lbs (per ASTM D 2794)
 - 2. Taber abrasion loss no greater than 60.2 mg (per ASTM D 4060)
 - 3. Adhesion to substrate of 1500 PSI (per ASTM D 4541)
 - 4. Salt fog resistance at 1400 hours (ASTM B117-85) to the following standards:
 - 5. Rust rating of 10 (D 610)
 - 6. Corrosion rating of 4 (D 1654)
 - 7. Blistering rating of 10 (D 714)
- D. Manufacturer shall provide a touch up kit for owners use.

- E. Powder coating will not be an accepted paint process.

2.11 BOLTS

- A. Forged Flanges: Type 316 stainless steel, ASTM A320/A320M-94 Grade B8M hex head bolts and ASTM A194/A194M-94 Grade 8M hex head nuts.

2.12 CONTROL ENCLOSURE

- A. Controls shall be housed in a NEMA 4 enclosure with integral latches.
- B. The control enclosure shall be constructed of powder coated carbon steel w/stainless steel hardware. AISI 61 grey powder coat finish interior and exterior.
- C. All indicating lights, reset buttons, selector switches and the operator interface device (OID) shall be mounted on enclosure door.
- D. All enclosure cut-outs to be done by laser for proper fit, sealing and coating retention.
- E. All internal components shall be mounted and secured to the removable back plate assembly.
- F. All internal components shall be mounted and secured to the removable back plate assembly. All equipment and wiring shall be mounted within the enclosure and labeled for proper identification.
- G. All adjustments and maintenance shall be able to be done from the front of the control enclosure.
- H. Entire control panel shall provide minimum of 22KA short circuit protection.
- I. A complete wiring circuit and legend with all terminals, components, and wiring identification shall be provided.
- J. Equipment shall be provided within the controls enclosure to assure compliance with current NEC and UL codes.
- K. Main disconnect shall be interlocked with door. Cabinet to be lockable.
- L. Conditions that shall be sent local PLC Control Panel:
 - 1. Pump Running Status
 - 2. Pump Fail Alarm Status
 - 3. System High Pressure Alarm
 - 4. System Low Pressure Alarm
- M. Panel face switches and lights:
 - 1. Individual pump run lights – Green
 - 2. Individual pump fail lights - Red
 - 3. General alarm light – Red
 - 4. Individual pump Hand/Off/Automatic switches
 - 5. Pump switches in the Hand position shall bypass the controller completely and force the pumps to run continuously. The only alarms remaining active shall be inlet pressure fault and system phase failure.
 - 6. System Manual-Off-Auto push button switch
 - 7. System Manual-Off-Auto push button switch in manual operation shall allow operator to start any pump manually by placing the pump switches in the Auto position. Operation of

the pumps in this mode shall include the full alarm system being active and protecting the pumps and system.

8. System Manual-Off-Auto push button switch in automatic operation shall allow controls to start pumps sequentially by placing the pump switches in the Auto position. Operation of the pumps in this mode shall include the full alarm system being active and protecting the pumps and system.

2.13 LIGHTNING AND SURGE ARRESTOR

- A. Electrical equipment shall be protected by a U.L. 1449 Second Edition Listed TVSS to suppress voltage surges on incoming power.
- B. Surge arrestor shall be connected to the line side of the pumping system landing lugs and shall be properly grounded.
- C. The device shall be rated according to IEEE C62.41.1-2002, C62.41.2-2002, and C63.45-2002 to provide a surge capacity of no less than 80kA per phase. 40 kA phase to neutral and phase to ground.
- D. Response time shall not be greater than 1/2 nanosecond.
- E. TVSS shall withstand no less than 5000 Category C3 (C High) impulses with less than 10% drift.
- F. Manufacturer of TVSS shall be ISO 9001:2000 certified.

2.14 CIRCUIT BREAKER AND MAIN DISCONNECT

- A. A circuit breaker main disconnect shall be provided to isolate all controls and motor starting equipment from incoming power.
- B. UL/CSA short-circuit interrupting capacity rating of the circuit breaker shall be not less than 22KA.
- C. Main disconnect shall have a through the door operator, and shall be sized in accordance with current NFPA 70 and UL requirements.
- D. Disconnect shall be as manufactured by Square D.

2.15 CONTROL POWER

- A. Power for the controls shall be provided by a control power transformer which shall provide 120 volt, single phase power for the pumping system control operation.
- B. Control power transformer shall not be used for any load other than controls.
- C. The control power transformer shall be protected on the primary side by control limiting fuses of adequate size and voltage rating.
- D. All control components on the load side of the transformer shall be protected by time delay circuit breakers of adequate size.
- E. The control power transformer shall be as manufactured by Acme.

2.16 VARIABLE FREQUENCY DRIVE

- A. Variable frequency drives shall not be used.

2.17 SKID CONDUIT

- A. All on skid conduit shall be flexible conduit with water tight connections at enclosure and termination device.
- B. All conduits shall be fastened to the skid every 24".

PART 3 - CONTROL SYSTEMS

3.1 PRESSURE CONTROL SYSTEMS

- A. The pressure control system shall start and stop the pump motors in response to changes in pump discharge pressure, as set forth herein. A time delay will be installed to prevent pressure spikes from turning off the pumps during pump start up.
- B. The pressure control system shall allow a pressure setpoint ranging from 53 psi to 43 psi.
- C. The manual mode of control shall start the pump(s) and allow the pump(s) to operate continuously until manually stopped by changing out of the manual mode of control. The automatic mode of control shall start and stop the pumps based on discharge pressure.
- D. The primary control system shall utilize pressure switches for primary pump control.
- E. In primary mode of control, rising and falling pump discharge pressure will be detected in the pump control panel and control the pumps as required using the setpoints input into the pressure switches.
- F. The pressure control system shall utilize a pump alternator to select the lead pump for a pumping cycle. Alternation of pumps shall occur at the end of a pumping cycle.

3.2 ALARMING

- A. Alarms and Protectives
 1. Low discharge pressure alarm (manual reset)
 2. Low Discharge Pressure alarm circuit shall shut down pumping system if discharge pressure reaches a predetermined low level. LED light, mounted in enclosure door, shall signal low discharge pressure.
 3. High discharge pressure alarm (manual reset)
 4. High Discharge Pressure alarm circuit shall shut down pumping system if discharge pressure reaches a predetermined high level. LED light shall signal high discharge pressure. Pumping system shall not operate until pressure is reduced and alarm has been reset.
 5. Phase failure alarm (manual reset)
 6. Individual motor phase failure and low voltage safety circuitry shall retire any pump that experiences low voltage, phase failure or phase unbalance at the load-side of each pump motor contactor (as sensed by the solid state overload relay). Each pump motor shall

- have its individual protective device and time delay to allow for transient low voltage during motor starting allowing maximum motor protection.
7. Separate system power phase failure and low voltage alarm circuit shall also be provided to retire the pumping system if it experiences low voltage, phase failure, or phase reversal as monitored at the load side of the control enclosure disconnect switch. Phase monitor shall have a time delay to allow for transient low voltage during motor starting allowing maximum motor protection. The individual pumps or pumping system shall not operate until the voltage problem has been corrected and alarm has been manually reset.
 8. Pump cycle fault alarm
 9. General alarm output indicating light
 10. Individual pump fault alarm (phase failure or overload, manual reset)
- B. Each active alarm shall be indicated on the face of the panel door clearly indicating the current fault. A general alarm light may also be illuminated for visual indication of an existing alarm.

PART 4 - EXECUTION

4.1 SYSTEM FACTORY FLOW TEST

- A. The entire pumping system shall be flow tested across its entire range at the manufacturer's facility prior to shipment.
- B. Factory flow test rig shall include flow meter and gauges that are NIST traceable. Test rig shall be able to supply power to the pumping system control panel to support the operation of all pumps.
- C. Check motor and control data plates for compatibility to site voltage. Install and test the station ground prior to connecting line voltage to station control panel.
- D. All electrical controls and circuits shall be included in the system test, as shall their interface to the motors and the outputs to the onsite PLC Control Panel.
- E. Prior to applying electrical power to any motors or control equipment, check all wiring for tight connection. Verify that protective devices (fuses and circuit breakers) conform to project design documents. Manually operate circuit breakers and switches to ensure operation without binding. Open all circuit breakers and disconnects before connecting utility power. Verify line voltage, phase sequence and ground before actual start-up
- F. System factory flow test results shall be provided in the form of an X-Y plot.
- G. Any failure in the flow test, either for any pump or for the system, shall be corrected by the manufacturer at his expense, and the test repeated until satisfactory results are obtained.

4.2 UNLOADING AND SETTING SUPERVISION

- A. Setting of the pumping system and connection to suction, discharge and power, anchoring of the pumping system, and thrust blocking of the suction and discharge piping that is connected to the pumping system shall be the responsibility of the installing contractor and not the manufacturer.
- B. Crane to off-load and set the pumping system onto the concrete slab shall be provided by installing contractor.

- C. Manufacturer shall inform the contractor, prior to system shipment, of the calculated weight of the pumping system.

4.3 INSTALLATION

- A. The general contractor shall assume full responsibility for coordination of the entire project, including verification that all structures, piping, coating systems and equipment components be compatible. The general contractor shall initially operate each equipment system, and shall make all necessary adjustments so that each system is placed in proper operation condition.
- B. Equipment and materials utilized for this project must be approved by the Engineer prior to installation. Approval for installation or incorporation in this project will be made only after submittal of manufacturer's shop and installation drawings, test results or other data as specified herein.
- C. Installation of equipment shall be in full conformance with the manufacturer shop drawings and requirements as approved by the Engineer. Wherever a conflict arises between manufacturer's instructions and the contract documents, the contractor shall follow the Engineer's decision at no additional cost to the owner.

4.4 MANUFACTURER'S SERVICES

- A. A manufacturer's representative for the equipment specified herein shall be present at the jobsite for the minimum person-days listed for the services hereinunder, travel time excluded:
 - 1. Installation, Startup and Testing Services:
 - 2. 1 person days for installation assistance, inspection, and certificate of Proper Installation.
 - 3. 1/2 person-day for functional and performance testing.
 - 4. Provide Qualifications of Manufacturer's Representative.
 - 5. Training Services:
 - 6. 1/2 person-day of prestart classroom or jobsite training of owner's personnel.
 - 7. Training of Owner's personnel shall be at such times and at such locations as required and approved by the Owner.
- B. The representative or factory service technician will inspect the completed installation. He will calibrate and adjust instrumentation, correct or supervise correction of defects or malfunctions, and instruct operating personnel in proper operation and maintenance procedures.

4.5 MANUFACTURER'S CERTIFICATES

- A. Provide Manufacturer's certificate(s) in accordance with Section 01 79 00, DEMONSTRATION AND TRAINING of Division 1, GENERAL REQUIREMENTS.

4.6 FIELD TEST:

- A. Prior to startup, all equipment described herein shall be inspected for proper alignment, quiet operation, proper connections, and satisfactory performance by means of a functional test. Tests shall demonstrate that all equipment is electrically, mechanically, structurally, and otherwise acceptable; it is safe and in optimum working condition; and conforms to the specified operating characteristics.

- B. The pump and motor assembly shall be field tested to verify vibration is not in excess of the limits stated in the latest revision of Hydraulic Institute and NEMA MG 1.
- C. The pumps, motors, and controls shall be given an operational test in accordance with the standards of the Hydraulic Institute. Recordings of the test shall substantiate the correct performance of the equipment at the design head, capacity, suction lift, speed and horsepower as herein specified.
- D. After construction, debris and foreign material has been removed from the point of suction, contractor shall supply clear water volume adequate to operate station through several pumping cycles. Observe and record operation of pumps, suction and discharge gage readings, ampere draw, pump controls, and controls. Check calibration of all instrumentation equipment, test manual control devices, and automatic control systems. Be alert to any undue noise, vibration or other operational problems.
- E. Units apparently failing to meet the Specifications to the satisfaction of the Engineer must be more accurately tested in accordance with Hydraulic Institute Standards. If the pump fails the second test, the unit will be rejected, and the Contractor shall furnish a unit that will be rejected, and the Contractor shall furnish a unit that will perform as specified.

END OF SECTION