CONTRACT DOCUMENTS

AND

SPECIFICATIONS

FOR

PROJECT NO. TMUA-W 18-19 C2
A.B. JEWELL WATER TREATMENT PLANT
CLARIFIER NO. 3 IMPROVEMENTS

ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY

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A New Kind of Energy™

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VOLUME II

CITY OF TULSA

TULSA, OKLAHOMA

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

A.B. JEWELL WATER TREATMENT PLANT
CLARIFIER 3 IMPROVEMENTS

Project No. TMUA-A 18-19

VOLUME II
DIVISION 01 THROUGH DIVISION 30

****

100 Percent Issued for Review

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JACOBS

Tulsa, Oklahoma

March 2022

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Project No. WFXQ2600 Copy No. _____

SECTION 00 01 07
SEALS PAGE

SPECIFICATIONS

DIVISION 01 – GENERAL REQUIREMENTS
DIVISION 02 – EXISTING CONDITIONS
DIVISION 09 – FINISHES
DIVISION 31 – EARTHWORK
DIVISION 33 – UTILITIES



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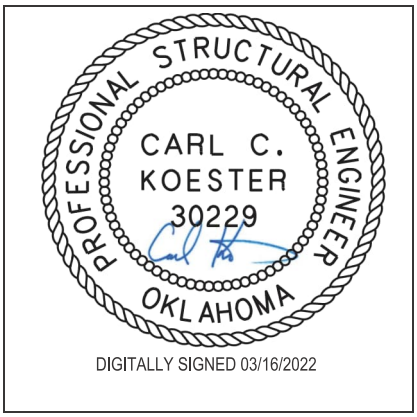
March 17, 2022

B. Luke Lenard

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SPECIFICATIONS

DIVISION 03 – CONCRETE
DIVISION 05 – METALS
DIVISION 41 – MATERIAL PROCESSING AND HANDLING EQUIPMENT



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March 16, 2022

Carl C. Koester

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SPECIFICATIONS

DIVISION 22 – PLUMBING
DIVISION 35 – WATERWAY AND MARINE CONSTRUCTION
DIVISION 40 – PROCESS INTEGRATION
40 05 15, 40 05 33, 40 27 00, 40 27 00.01, 40 27 00.03, 40 27 00.08, 40 27 00.10, 40 27 00.11, 40 27 00.13, 40 27 01, 40 27 02, 40 42 13, 40 80 01
DIVISION 43 – PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT
DIVISION 44 – POLLUTION CONTROL EQUIPMENT



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Bryan A. Youker

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SPECIFICATIONS
DIVISION 26 - ELECTRICAL



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SPECIFICATIONS
DIVISION 40 – PROCESS INTEGRATION
40 90 01



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END OF SECTION

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Pages

TABLE OF CONTENTS

SPECIFICATIONS

VOLUME II

DIVISION 01—GENERAL REQUIREMENTS

01 11 00	Summary of Work	1- 1
01 29 00	Payment Procedures	1- 13
01 31 13	Project Coordination	1- 6
01 31 19	Project Meetings	1- 3
01 32 00	Construction Progress Documentation	1- 7
01 33 00	Submittal Procedures	1- 9
	Supplement:	
	Transmittal of Contractor's Submittal	1- 1
01 42 13	Abbreviations and Acronyms	1- 5
01 43 33	Manufacturers' Field Services	1- 5
	Supplements:	
	Manufacturer's Certificate of Compliance	1- 1
	Manufacturer's Certificate of Proper Installation	1- 1
01 45 16.13	Contractor Quality Control	1- 9
01 45 33	Special Inspection, Observation, and Testing	1- 5
01 50 00	Temporary Facilities and Controls	1- 12
01 61 00	Common Product Requirements	1- 8
01 77 00	Closeout Procedures	1- 4
01 78 23	Operation and Maintenance Data	1- 8
	Supplement:	
	Maintenance Summary Form	1- 2
01 88 15	Anchorage and Bracing	1- 6
01 91 14	Equipment Testing and Facility Startup	1- 6
	Supplements:	
	Unit Process Startup Form	1- 1
	Facility Performance Demonstration/Certification Form	1- 1

DIVISION 02—EXISTING CONDITIONS

02 41 00	Demolition	1- 7

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Pages

DIVISION 03—CONCRETE

03 01 32	Repair of Vertical and Overhead Concrete Surfaces	1- 16
03 01 33	Repair of Horizontal Concrete Surfaces	1- 13
03 30 10	Structural Concrete	1- 26
	Supplements:	
	Concrete Mix Design, Class 5000F3S1P2C2	1- 2
	Concrete Mix Design, Class 4500F1S1P0C1	1- 2
03 39 00	Concrete Curing	1- 4
03 62 00	Nonshrink Grouting	1- 6
	Supplement:	
	24-hour Evaluation of Nonshrink Grout Testing Form and Grout Testing Procedures	1- 3
03 63 00	Concrete Doweling	1- 5
03 64 23	Crack Repair Injection Grouting	1- 9

DIVISION 04—NOT USED

DIVISION 05—METALS

05 05 23	Welding	1- 5
	Supplement:	
	Welding and Nondestructive Testing Table	1- 1
05 50 00	Metal Fabrications	1- 21
05 52 16	Aluminum Railings	1- 9
05 53 00	Metal Gratings	1- 5

DIVISION 06 THROUGH DIVISION 08—NOT USED

DIVISION 09—FINISHES

09 90 00	Painting and Coating	1- 23
	Supplements:	
	Paint System Data Sheet (PSDS)	1- 1
	Paint Product Data Sheet (PPDS)	1- 1

DIVISION 10 THROUGH DIVISION 21—NOT USED

DIVISION 22—PLUMBING

22 10 01	Plumbing Piping and Accessories	1- 6

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Pages

DIVISION 23 THROUGH DIVISION 25—NOT USED

DIVISION 26—ELECTRICAL

26 05 01	Electrical	1- 45
26 29 23	Low-Voltage Adjustable Frequency Drive System	1- 17

DIVISION 27 THROUGH DIVISION 30—NOT USED

VOLUME II con't

DIVISION 31—EARTHWORK

31 10 00	Site Clearing	1- 3
31 23 13	Subgrade Preparation	1- 4
31 23 16	Excavation	1- 4
31 23 19.01	Dewatering	1- 2
31 23 23	Fill and Backfill	1- 10
31 23 23.15	Trench Backfill	1- 8
31 23 24	Compaction Grouting	1- 7
31 32 19.16	Geotextile	1- 8
31 41 00	Shoring	1- 2

DIVISION 32—NOT USED

DIVISION 33—UTILITIES

33 13 00	Disinfection of Water Utility Distribution Facilities	1- 5

DIVISION 34—NOT USED

DIVISION 35—WATERWAY AND MARINE CONSTRUCTION

35 20 16.25	Fabricated Slide Gates	1- 10

DIVISION 36 THROUGH DIVISION 39—NOT USED

DIVISION 40—PROCESS INTEGRATION

40 05 15	Piping Support Systems	1- 8
	Supplement:	
	Table 1: Nonchemical Areas	1- 1
40 05 33	Pipe Heat Tracing	1- 6
40 27 00	Process Piping—General	1- 17

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Pages

40 27 00.01	Cement-Mortar-Lined Ductile Iron Pipe and Fittings Data Sheet	1- 2
40 27 00.03	Carbon Steel Pipe and Fittings—General Service Data Sheet.	1- 5
40 27 00.08	Stainless Steel Pipe and Fittings-General Service Data Sheet.	1- 2
40 27 00.10	Polyvinyl Chloride (PVC) Pipe and Fittings Data Sheet	1- 1
40 27 00.11	Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings Data Sheet	1- 2
40 27 00.13	Copper and Copper Alloy Pipe, Tubing, and Fittings Data Sheet	1- 1
40 27 01	Process Piping Specialties	1- 8
40 27 02	Process Valves and Operators	1- 17
40 42 13	Process Piping Insulation	1- 7
	Supplement:	
	Service and Insulation Thickness Table	1- 1
40 80 01	Process Piping Leakage Testing	1- 4
40 90 01	Instrumentation and Control for Process Systems	1- 68
	Supplements:	
	Component Specifications	1- 25
	Instrument List	1- 1
	Control Panel Schedule	1- 1
	I/O Lists	1- 13
	Loop Specifications	1- 35
	Surge Suppressor Products Table	1- 3
	Wiring Diagram Examples	1- 9
	Preparation for Testing and Functional Test Forms	1- 6
	Drawing 24381, Markup on Sludge Pump Station Wiring	1- 8

DIVISION 41—MATERIAL PROCESSING AND HANDLING EQUIPMENT

41 22 23.19	Monorail Hoists	1- 7
	Supplements:	
	Hoist/Monorail Data Sheet	1- 1
	Hoist/Monorail Dimension Sheet	1- 1
	Induction Motor Data Sheet	1- 1

DIVISION 42—NOT USED

DIVISION 43—PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

43 22 56	Rapid Mixers	1- 9

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Pages

DIVISION 44—POLLUTION CONTROL EQUIPMENT

44 42 28	Stainless Steel Baffle System	1- 7
44 42 56.05	Sump Pump	1- 4
	Supplement:	
	Sump Pump Schedule	1- 1
44 42 56.09	Non-Clog Dry-Pit Centrifugal Pumps	1- 12
	Supplement:	
	Non-Clog Dry-Pit Centrifugal Pump Data Sheet	1- 4
44 42 63	Hose-Less Solids Collection System	1- 22
	Supplement:	
	Hose-Less Solids Collection System Data Sheet	1- 1
44 44 36	Horizontal Paddle Flocculation System	1- 14
	Supplement:	
	Flocculation Equipment Data Sheet	1- 2
44 44 57	Parallel Plate Settler System	1- 10

DIVISION 45 THROUGH DIVISION 49—NOT USED

VOLUME III

DRAWINGS

END OF SECTION

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SECTION 01 11 00
SUMMARY OF WORK

PART 1 GENERAL

1.01 WORK COVERED BY CONTRACT DOCUMENTS

A. The completed Work will provide Owner with an improved Clarifier No. 3 at the A. B. Jewell Water Treatment Plant. The Project includes but it is not limited to:

1. Demolition of existing clarifier mechanisms, flocculators, and sludge removal mechanisms.
2. Investigation of subgrade underneath clarifier and filling of voids as directed by Owner.
3. Installation of concrete coatings in interior of rapid mix and flocculation section of the clarifier and repair of joints and cracks in the clarifier.
4. Installation of new flocculation stage divider walls and new diffusion walls.
5. Installation of new flocculators and drive mechanisms.
6. Installation of sludge collector system with drives along with electrical and control components.
7. Installation of sludge collection piping, pumps, and valves.
8. Installation of plate settlers.
9. Modifications to existing Raw Water Controller Vault.
10. Modifications to existing Sludge Pump Stations No. 1 and 2.
11. Modifications to existing SCADA system.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 29 00
PAYMENT PROCEDURES

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Schedule of Values: Submit on Contractor's standard form.
2. Application for Payment.
3. Final Application for Payment.

1.01 MEP ALLOWANCE

A. An allowance as shown in the Proposal has been provided in the Contract for various mechanical, electrical, and plumbing (MEP) work.

B. The allowance shall be used for the cost of materials, labor, installation, and overhead and profit, in accordance with GC-26, for additional MEP work that is not identified in the Construction Documents and Drawings, and not included in the base bid lump sum.

C. The allowance shall be used only at the discretion of the Authority.

D. The Contractor shall provide to the Authority Representative, a written request for the use of the allowance, with a schedule of values and associated backup information.

E. Contractor shall proceed with work included in the allowance only after receiving a written order for the Authority Representative authorizing such work. Proceeding with work in the allowance without a written order from the Authority Representative will be at the Contractor's cost.

1.02 SCHEDULE OF VALUES

A. Prepare a separate Schedule of Values for each schedule of the Work under the Agreement.

B. Upon request of Engineer, provide documentation to support the accuracy of the Schedule of Values.

C. Unit Price Work: Reflect unit price quantity and price breakdown from conformed Bid Form.

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D. Lump Sum Work:

1. Reflect specified cash allowances and alternates, as applicable.
2. List bonds and insurance premiums, mobilization, demobilization, preliminary and detailed progress schedule preparation, equipment testing, facility startup, and contract closeout separately.
3. Break down by Division 02 through 49 with appropriate subdivision of each Specification.

E. An unbalanced or front-end loaded schedule will not be acceptable.

F. Summation of the complete Schedule of Values representing all the Work shall equal the Contract Price.

G. Submit Schedule of Values on a CD or by email, in a spreadsheet format compatible with latest version of Excel.

1.03 APPLICATION FOR PAYMENT

A. Transmittal Summary Form: Attach one Summary Form with each detailed Application for Payment for each schedule and include Request for Payment of Materials and Equipment on Hand as applicable. Execute certification by authorized officer of Contractor.

B. Use detailed Application for Payment Form suitable to Engineer.

C. Provide separate form for each schedule as applicable.

D. Include accepted Schedule of Values for each schedule or portion of lump sum Work and the unit price breakdown for the Work to be paid on a unit priced basis.

E. Include separate line item for each Change Order and Work Change Directive executed prior to date of submission. Provide further breakdown of such as requested by Engineer.

F. Preparation:

1. Round values to nearest dollar.
2. Submit Application for Payment, including a Transmittal Summary Form and detailed Application for Payment Form(s) for each schedule as applicable, a listing of materials on hand for each schedule as applicable, and such supporting data as may be requested by Engineer.

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1.04 MEASUREMENT—GENERAL

A. Weighing, measuring, and metering devices used to measure quantity of materials for Work shall be suitable for purpose intended and conform to tolerances and specifications as specified in National Institute of Standards and Technology, Handbook 44.

B. Whenever pay quantities of material are determined by weight, material shall be weighed on scales furnished by Contractor and certified accurate by state agency responsible. Weight or load slip shall be obtained from weigher and delivered to Owner's representative at point of delivery of material.

C. If material is shipped by rail, car weights will be accepted provided that actual weight of material only will be paid for and not minimum car weight used for assessing freight tariff, and provided further that car weights will not be acceptable for material to be passed through mixing plants.

D. Vehicles used to haul material being paid for by weight shall be weighed empty daily and at such additional times as required by Engineer. Each vehicle shall bear a plainly legible identification mark.

E. Materials that are specified for measurement by the cubic yard measured in the vehicle shall be hauled in vehicles of such type and size that actual contents may be readily and accurately determined. Unless all vehicles are of uniform capacity, each vehicle must bear a plainly legible identification mark indicating its water level capacity. Vehicles shall be loaded to at least their water level capacity. Loads hauled in vehicles not meeting above requirements or loads of a quantity less than the capacity of the vehicle, measured after being leveled off as above provided, will be subject to rejection, and no compensation will be allowed for such material.

F. Where measurement of quantities depends on elevation of existing ground, elevations obtained during construction will be compared with those shown on Drawings. Variations of 1 foot or less will be ignored, and profiles shown on Drawings will be used for determining quantities.

G. Units of measure shown on Bid Form shall be as follows, unless specified otherwise.

Item	Method of Measurement
AC	Acre—Field Measure by Engineer
CY	Cubic Yard—Field Measure by Engineer within limits specified or shown

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Item	Method of Measurement
CY-VM	Cubic Yard—Measured in Vehicle by Volume
EA	Each—Field Count by Engineer
GAL	Gallon—Field Measure by Engineer
HR	Hour
LB	Pound(s)—Weight Measure by Scale
LF	Linear Foot—Field Measure by Engineer
SF	Square Foot
SY	Square Yard
TON	Ton—Weight Measure by Scale (2,000 pounds)

1.05 PAYMENT

A. General:

1. The following items shall be bid as shown on the Estimate of Quantities of the Bid Proposal. The description below summarizes the elements of the work that are to be included in each item but they are not intended to represent a complete list of the required work for a completed job. Rather, the descriptions are intended to serve as guidelines for the proper distribution of the bid price. Any item not specifically described but required by the Drawings, Contract Documents, and Specifications shall be included in the appropriate items. The lump sum Bid items shall be broken down for the purpose of monthly progress payment as outlined below. Breakdown of the lump sum items shall be provided by the apparent low Bidder within 48 hours after the Bid opening.
2. The Authority pays vendor invoices directly based upon written documentation submitted to and approved by the Authority.

B. Unit Price Pay items:

1. Mobilization:
   a. This item includes mobilization and demobilization. A maximum of 5 percent of the total base bid is allowed in the bid proposal for mobilization and shall be paid for on an each basis in the following manner:
      1) 50 percent on the first pay estimate.

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2) 35 percent on the pay estimate that shows 50 percent completion of the work, not including allowances for stored materials.
3) 15 percent on the final pay estimate.

2. Erosion Control: Provide all materials, labor, equipment and associated items necessary to provide erosion control in accordance with the Contract Documents. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
3. Traffic Control: Provide all materials, labor, equipment and associated items necessary to provide traffic control. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
4. Demolition: Provide all materials, labor, equipment and associated items necessary for all project demolition, hauling and disposal costs. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
5. 84-Inch Flow Meter: Provide all materials, labor, equipment and associated items necessary to install flow meter for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
6. Rapid Mix Box No. 3 - Construct Metal Stairs: Provide all materials, labor, equipment and associated items necessary to install stairs including all prep work, surface demolition and restoration, connections to existing, concrete landing, and hardware needed for complete installation. Excludes Handrail. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
7. Rapid Mix Box No. 3 - Replace Existing Grating with New Aluminum Grating and Stainless Steel Beams and Plates: Provide all materials, labor, equipment and associated items necessary to install aluminum grating, beams, supports and fasteners needed for complete installation. This item shall be paid for on a square foot (SF) basis.
8. Rapid Mix Box No. 3 - 1-inch Aluminum Chlorohydrate CPVC Pipe with Fittings and Valves: Provide all materials, labor, equipment and associated items necessary to install 1-inch pipe including piping materials, fittings, valves, hangers, and connections to existing for a complete installation. This item shall be paid for on a linear foot (LF) basis.
9. Rapid Mix Box No. 3 - 1-inch Coagulant Aid Polymer CPVC Pipe with Fittings and Valves: Provide all materials, labor, equipment and associated items necessary to install 1-inch pipe including piping materials, fittings, valves, hangers, and connections to existing for a complete installation. This item shall be paid for on a linear foot (LF) basis.

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10. Rapid Mix Box No. 3 - 48-inch Influent Slide Gate: Provide all materials, labor, equipment and associated items necessary to install gate including all prep work, grouting, and connections for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
11. Rapid Mix Box No. 3 - Rapid Mixer: Provide all materials, labor, equipment and associated items necessary to install mixers including all hardware and mounting material, testing, setup and commissioning needed for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
12. Raw Water Controller Vault - Access Structure: Provide all materials, labor, equipment and associated items necessary to install concrete stair including all needed utility relocation, excavation, backfill, compaction, dewatering, shoring, formwork, reinforcing, concrete and connections to existing needed for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
13. Raw Water Controller Vault - Aluminum Door and Frame: Provide all materials, labor, equipment and associated items necessary to install door and frame including sawcut and removal of existing concrete, door, frame and hardware for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
14. Raw Water Controller Vault - Concrete Coatings: Provide all materials, labor, equipment and associated items necessary to install concrete coatings on new and existing surfaces as indicated on Drawings for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
15. Raw Water Controller Vault - Exhaust Fan: Provide all materials, labor, equipment and associated items necessary to install exhaust fan including concrete cores and surface restoration required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
16. Raw Water Controller Vault - Remove and Replace 36-inch Isolation Butterfly Valve: Provide all materials, labor, equipment and associated items necessary to remove, haul and dispose of existing valve and install new valve including locating, trenching, backfill, compaction, dewatering, shoring, draining fittings and connections needed to remove existing valve and install new as required for a complete installation. Valve removal requires a plant shutdown. Maximum shutdown time is 24 hours, but Contractor should plan for 8 hours. Contractor shall coordinate with Engineer and Plant staff and provide at least 30 days' notice of planned valve removal. Isolation valves for Clarifier No. 1 and Clarifier No. 2 will be provided by Owner. Contractor shall purchase

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Isolation Valve for Clarifier 3 and install all three valves. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.

17. Clarifier No. 3 - Ground Penetrating Radar: Provide all materials, labor, equipment and associated items to scan entire base slab of structure and map out any areas of under slab voids for use in developing a repair procedure. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by Engineer.
18. Clarifier No. 3 - Inject Grout Under Slab: Provide all materials, labor, equipment and associated items to inject grout under base slab to repair voids. This item shall be paid for on a square foot (SF) basis.
19. Clarifier No. 3 - Wall Crack Injection: Provide all materials, labor, equipment and associated items to inject cracks in existing walls. This item shall be paid for on a linear foot (LF) basis.
20. Clarifier No. 3 - Floor Joint Chemical Injection: Provide all materials, labor, equipment and associated items to inject floor joints. This item shall be paid for on a linear foot (LF) basis.
21. Clarifier No. 3 – Walkway Crack Injection: Provide all materials, labor, equipment and associated items to inject cracks in walkways. This item shall be paid for on a linear foot (LF) basis.
22. Clarifier No. 3 - Repair Deficient Concrete Surfaces: Provide all materials, labor, equipment and associated items to repair deficient concrete surfaces. This item shall be paid for on a square foot (SF) basis.
23. Clarifier No. 3 - Concrete Walls: Provide all materials, labor, equipment and associated items necessary to install concrete walls and concrete wall extensions within Clarifier No. 2 including all surface preparation, drill and epoxied dowels, formwork, reinforcement, and concrete material as required for a complete installation. This item shall be paid for on a cubic yard (CY) basis.
24. Clarifier No. 3 - Concrete Columns at Diffuser Wall: Provide all materials, labor, equipment and associated items necessary to install concrete columns for diffuser wall including all surface preparation, drill and epoxied dowels, formwork, reinforcement, and concrete material as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
25. Clarifier No. 3 - Concrete Pier Supports at Flocculator Paddles Detail 2: Provide all materials, labor, equipment and associated items necessary to install concrete supports including all surface preparation, drill and epoxied dowels, formwork, reinforcement, and concrete material as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.

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26. Clarifier No. 3 - Concrete Pier Supports at Flocculator Paddles Detail 4: Provide all materials, labor, equipment and associated items necessary to install concrete supports including all surface preparation, drill and epoxied dowels, formwork, reinforcement, and concrete material as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
27. Clarifier No. 3 - Support Column Foundation Type A: Provide all materials, labor, equipment and associated items necessary to install Type A column foundations including core drilling, sawcutting, concrete removal, preparation, reinforcement, waterstop, embeds, and concrete materials as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
28. Clarifier No. 3 - Support Column Foundation Type B: Provide all materials, labor, equipment and associated items necessary to install Type B column foundations including all preparation, reinforcement, waterstop, embeds, and concrete materials as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
29. Clarifier No. 3 - Concrete Elevated Deck: Provide all materials, labor, equipment and associated items necessary to install elevated concrete deck including all surface preparation, drill and epoxied dowels, formwork, reinforcement, and concrete material as required for a complete installation. This item shall be paid for on a cubic yard (CY) basis.
30. Clarifier No. 3 - Concrete Fill: Provide all materials, labor, equipment and associated items necessary to install concrete fill within the clarifier including all surface preparation, drill and epoxied dowels, formwork, reinforcement, and concrete material as required for a complete installation. This item shall be paid for on a cubic yard (CY) basis.
31. Clarifier No. 3 - Construct Metal Stairs: Provide all materials, labor, equipment and associated items necessary to install stair including all prep work, surface demolition and restoration, connections to existing, concrete landing, and hardware needed as required for a complete installation. Excludes Handrail. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
32. Clarifier No. 3 - Aluminum Grating and Removable Hatch at Existing Opening: Provide all materials, labor, equipment and associated items necessary to install checkered plate and hatch including checkered plate cover, access hatch, concrete patching and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
33. Clarifier No. 3 - Aluminum Grating: Provide all materials, labor, equipment and associated items necessary to install grating including

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grating and embeds as required for a complete installation. This item shall be paid for on a square foot (SF) basis.

34. Clarifier No. 3 - Ladder: Provide all materials, labor, equipment and associated items necessary to install ladders including all prep work, connections to existing, and hardware needed for complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
35. Clarifier No. 3 - Flocculation Stage Dividers: Provide all materials, labor, equipment and associated items necessary to install dividers including divider frames, and mounting hardware as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
36. Clarifier No. 3 - Concrete Coatings: Provide all materials, labor, equipment and associated items necessary to install coatings on new and existing surfaces as indicated on drawings including coating within basin, channels, and rapid mix structure and exterior coating to 1 foot below existing grade as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
37. Clarifier No. 3 – 4-inch Stainless Steel Pipe with Fittings: Provide all materials, labor, equipment and associated items necessary to install 4-inch stainless steel pipe including pipe, fittings, valves and supports as required for a complete installation. This item shall be paid for on a linear foot (LF) basis.
38. Clarifier No. 3 - 4-inch Plug Valve: Provide all materials, labor, equipment and associated items necessary to install plug valve including valve and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
39. Clarifier No. 3 – 12-inch DR DI Pipe with Fittings: Provide all materials, labor, equipment and associated items necessary to install 12-inch DR DI pipe including pipe, fittings, valves and supports as required for a complete installation. This item shall be paid for on a linear foot (LF) basis.
40. Clarifier No. 3 - Water Monitor: Provide all materials, labor, equipment and associated items necessary to install water monitors including anchorage and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
41. Clarifier No. 3 - 48-inch Effluent Slide Gate: Provide all materials, labor, equipment and associated items necessary to install slide gate including prep work, grouting and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.

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42. Clarifier No. 3 - Sludge Collectors: Provide all materials, labor, equipment and associated items necessary to install sludge collectors including all prep work, grouting and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
43. Clarifier No. 3 - Plate Settlers including Effluent Troughs and Platform Walkway: Provide all materials, labor, equipment and associated items necessary to install plate settlers, effluent troughs and platform walkway including all prep work, grouting and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
44. Clarifier No. 3 - Water Flocculators, Drive and Paddle Assembly: Provide all materials, labor, equipment and associated items necessary to install flocculators, drives and paddle assemblies including all prep work, grouting and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
45. Sludge Pump Station No. 1 - Access Structure: Provide all materials, labor, equipment and associated items necessary to install concrete stair including all needed utility relocation, excavation, backfill, compaction, dewatering, shoring, formwork, reinforcing, concrete and connections to existing needed for a complete installation. Relocate the existing metal steps to the south side and adjusting handrail for the new location. Relocate PLC cabinet and conduit as shown on Drawings including new concrete slab for the PLC cabinet. This item includes all work (electrical, I&C, grading, handrail, structural, etc.) required to relocate the existing equipment and install the new stairs. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
46. Sludge Pump Station No. 2 - 4-inch Sludge DI Pipe w/Fittings: Provide all materials, labor, equipment and associated items necessary to install 4-inch DI pipe including piping materials, connections, supports and coatings as required for a complete installation. This item shall be paid for on a linear foot (LF) basis.
47. Sludge Pump Station No. 2 - 4-inch Plug Valve: Provide all materials, labor, equipment and associated items necessary to install 4-inch plug valve including materials and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
48. Sludge Pump Station No. 2 - 4-inch Check Valve: Provide all materials, labor, equipment and associated items necessary to install 4-inch check valve including materials and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.

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49. Sludge Pump Station No. 2 - Sludge Pump: Provide all materials, labor, equipment and associated items necessary to install sludge pump including prep work, materials grouting and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
50. Handrail: Provide all materials, labor, equipment and associated items necessary to install all project handrail including stair mounted handrail and all mounting hardware as required for a complete installation. This item shall be paid for on a linear foot (LF) basis.
51. Buried 4-inch W1 DI Pipe with Fittings: Provide all materials, labor, equipment and associated items necessary to install 4-inch DI pipe including piping materials, fittings, supports, coatings and connections as required for a complete installation. This item shall be paid for on a linear foot (LF) basis.
52. Electrical at Rapid Mix Box No. 3: Provide all materials, labor, equipment and associated items necessary to install electrical system. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
53. Electrical at Clarifier No. 3: Provide all materials, labor, equipment and associated items necessary to install electrical system. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
54. Electrical at Raw Water Control Vault: Provide all materials, labor, equipment and associated items necessary to install electrical system. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
55. Electrical at Sludge Pump Station No. 2: Provide all materials, labor, equipment and associated items necessary to install electrical system. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
56. I&C at Clarifier No. 3: Provide all materials, labor, equipment and associated items necessary to install Instrumentation and Control system. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
57. I&C at Sludge Pump Station No. 2: Provide all materials, labor, equipment and associated items necessary to install Instrumentation and Control system. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
58. Clarifier 2 and Clarifier 3 Venturis and Butterfly Valves: Provide all materials, labor, equipment and associated items necessary to remove, haul and dispose of existing Venturi pipe and butterfly valve and install new Venturi pipe and butterfly valve including locating, dewatering, shoring, draining fittings and connections needed to remove existing Venturi and valve and install new as required for a complete

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installation. Removal may require a plant shutdown. Maximum shutdown time is 24 hours, but Contractor should plan for 8 hours. Contractor shall coordinate with Engineer and Plant staff and provide at least 30 days' notice of planned removal. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.

59. Clarifier No. 4 - Water Monitor: Provide all materials, labor, equipment and associated items necessary to install water monitors including anchorage and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
60. Clarifier No. 1 - Water Monitor: Provide all materials, labor, equipment and associated items necessary to install water monitors including anchorage and connections as required for a complete installation. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
61. Owner's Allowance:
    a. Allowance for various work not identified in the Contract Documents:
        1) Allowance $10,000.
        2) The allowance shall be used only at the discretion of the City of Tulsa. Any allowance balance remaining at the completion of the project will be credited back to the City of Tulsa on the final Application for Payment submitted by the Contractor.
62. Construction As-Builts: This pay item includes all work necessary for the completion of the Construction As-Builts and provided to the Engineers as required by the Contract Documents and shall include an as-built survey, including location and elevations of equipment and structures. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
63. Lucity Database Asset Management Spreadsheet: This pay item includes all work necessary for the completion of the Lucity database asset management spreadsheet as required by the Contract Documents. Payment of this line item shall be on the basis of a Schedule of Values submitted by the Contractor and approved by the Engineer as a basis for monthly progress payments. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.
64. All Other Work Specified and Shown on Drawings or Specifications but not Covered in Other Bid Items: Provide all materials, labor, equipment and associated items necessary to install items required by drawings or specifications but not covered by other bid items. This item shall be paid for on a unit basis of each (EA) using a breakdown approved by the Engineer.

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1.06 NONPAYMENT FOR REJECTED OR UNUSED PRODUCTS

A. Payment will not be made for following:

1. Loading, hauling, and disposing of rejected material.
2. Quantities of material wasted or disposed of in manner not called for under Contract Documents.
3. Rejected loads of material, including material rejected after it has been placed by reason of failure of Contractor to conform to provisions of Contract Documents.
4. Material not unloaded from transporting vehicle.
5. Defective Work not accepted by Owner.
6. Material remaining on hand after completion of Work.

1.07 PARTIAL PAYMENT FOR STORED MATERIALS AND EQUIPMENT

A. Partial Payment: No partial payments will be made for materials and equipment delivered or stored unless Shop Drawings and preliminary operation and maintenance data is acceptable to Engineer.

B. Final Payment: Will be made only for products incorporated in Work; remaining products, for which partial payments have been made, shall revert to Contractor unless otherwise agreed, and partial payments made for those items will be deducted from final payment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 31 13
PROJECT COORDINATION

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational:

1. Statement of Qualification (SOQ) for land surveyor or civil engineer.
2. Photographs:
   a. Digital Images: Submit on DVD or compact disc within 4 days of being taken.
3. Video Recordings: Submit two copies, including updated copy of project video log, within 5 days of being taken.

1.02 PROJECT MILESTONES

A. General: Include the Milestones specified herein as a part of the Progress Schedule required under Section 01 32 00, Construction Progress Documentation.

B. Specific Project Milestones:

1. Submittal of Plate Settlers, Flocculators, and Hoseless Sludge Removal System, sludge pumps and sluice gates within 15 calendar days of receiving Notice To Proceed.
2. All work related to Clarifier No. 3: Plant Staff will drain and clean Clarifier No. 3 no earlier than October 1, 2022 for the Contractor's use.
3. Contractor will complete Clarifier No. 3 modifications by April 1, 2023, providing up to 30 days of functional testing, such that the Milestone date of returning the Clarifier to service by May 1, 2023 is completed.
4. Although not a specific milestone, it is noted that the Contractor can begin Work outside of the Clarifiers as needed (prior to draining and cleaning of Clarifier) to meet the overall construction timeline.

1.03 FACILITY OPERATIONS

A. Continuous operation of Owner's facilities is of critical importance. Schedule and conduct activities to enable existing facilities to operate continuously, unless otherwise specified.

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B. Perform Work continuously during critical connections and changeovers, and as required to prevent interruption of Owner's operations.

C. When necessary, plan, design, and provide various temporary services, utilities, connections, temporary piping and heating, access, and similar items to maintain continuous operations of Owner's facility.

D. Do not close lines, open or close valves, or take other action which would affect the operation of existing systems, except as specifically required by the Contract Documents and after authorization by Owner and Engineer. Such authorization will be considered within 48 hours after receipt of Contractor's written request.

E. Process or Facility Shutdown:

1. Shutdowns maybe required at some time during the Work as specified on Coordination and Construction Constraint Items table located at the end of this Section as a Supplement.
2. Provide 14 calendar days advance written request for approval of need to shut down a process or facility to Owner and Engineer.
3. Power outages will be considered upon 48 hours written request to Owner and Engineer. Describe the reason, anticipated length of time, and areas affected by the outage. Provide temporary provisions for continuous power supply to critical facility components.

F. Do not proceed with Work affecting a facility's operation without obtaining Owner's and Engineer's advance approval of the need for and duration of such Work.

G. Relocation of Existing Facilities:

1. During construction, it is expected that minor relocations of Work will be necessary.
2. Provide complete relocation of existing structures and Underground Facilities, including piping, utilities, equipment, structures, electrical conduit wiring, electrical duct bank, and other necessary items.
3. Use only new materials for relocated facility. Match materials of existing facility, unless otherwise shown or specified.
4. Perform relocations to minimize downtime of existing facilities.
5. Install new portions of existing facilities in their relocated position prior to removal of existing facilities, unless otherwise accepted by Engineer.

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1.04 CONSTRUCTION PHOTOGRAPHS

A. General:

1. Photographically document all phases of the Project including preconstruction, construction progress, and post-construction.
2. Engineer shall have the right to select the subject matter and vantage point from which photographs are to be taken.

B. Preconstruction and Post-Construction:

1. After Effective Date of the Agreement and before Work at Site is started, and again upon issuance of Substantial Completion, take a minimum of 48 photographs of Site and property adjacent to perimeter of Site.
2. Particular emphasis shall be directed to structures both inside and outside the Site.
3. Format: Digital, minimum resolution of 2,500 pixels by 1,900 pixels and 24-bit, millions of color.

C. Construction Progress Photos:

1. Photographically demonstrate progress of construction, showing every aspect of Site and adjacent properties as well as interior and exterior of new or impacted structures.
2. Weekly: Take 48 photographs using digital, minimum resolution of 2,500 pixels by 1,900 pixels and 24-bit, millions of color.
3. Actual number of photos shall be sufficient to completely document the condition of the construction site.

D. Digital Images:

a. Electronic image shall have date taken embedded into image.
b. Archive using a commercially available photo management system.
c. Label each disk with Project and Owner’s name, and month and year images were produced.

1.05 AUDIO-VIDEO RECORDINGS

A. Prior to beginning the Work on Construction Site or of a particular area of the Work, and again within 10 days following date of Substantial Completion, videograph Construction Site and property adjacent to Site.

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B. In the case of preconstruction recording, no Work shall begin in the area prior to Engineer's review and approval of content and quality of video for that area.

C. Particular emphasis shall be directed to physical condition of existing vegetation, structures, and pavements within construction area.

D. Engineer shall have right to select subject matter and vantage point from which videos are to be taken.

E. Video Format and Quality:

1. DVD format, with sound.
2. Video:
   a. Produce bright, sharp, and clear images with accurate colors, free of distortion and other forms of picture imperfections.
   b. Electronically, and accurately display the month, day, year, and time of day of the recording.
3. Audio:
   a. Audio documentation shall be done clearly, precisely, and at a moderate pace.
   b. Indicate date, project name, and a brief description of the location of recording, including:
      1) Facility name.
      2) Direction of coverage, including engineering stationing, if applicable.

F. Documentation:

1. DVD Label:
   a. DVD number (numbered sequentially, beginning with 001).
   b. Project name.
   c. Date and time of coverage.
2. Project Video Log: Maintain an ongoing log that incorporates above noted label information for DVDs on Project.

1.06 REFERENCE POINTS AND SURVEYS

A. Location and elevation of bench marks are shown on Drawings.

B. Contractor's Responsibilities:

1. Provide additional survey and layout required to layout the Work.
2. Check and establish exact location of existing facilities prior to construction of new facilities and any connections thereto.

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3. Maintain complete accurate log of survey work as it progresses as a Record Document.
4. On request of Engineer, submit documentation.
5. Provide competent employee(s), tools, stakes, and other equipment and materials as Engineer may require to:
    a. Check layout, survey, and measurement work performed by others.
    b. Measure quantities for payment purposes.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SALVAGE OF MATERIALS

A. Materials to be salvaged include:

1. Flocculator paddles and shafts.
2. Clarifier mechanisms.
3. Stairs as shown on Drawings.

B. Salvage materials for Owners use.

1. Remove material with extreme care so as not to damage for future use.
2. Promptly remove salvaged materials from Work area.
3. Store materials where instructed by Owner.

C. Meet with Engineer prior to starting to dismantle equipment or piping designated to be salvaged. Engineer will indicate locations where equipment is to be disconnected.

D. Clean and protect equipment from dust, dirt, natural elements, and store as directed.

3.02 CUTTING, FITTING, AND PATCHING

A. Cut, fit, adjust, or patch Work and work of others, including excavation and backfill as required, to make Work complete.

B. Obtain prior written authorization of Engineer and Owner before commencing Work to cut or otherwise alter:

1. Structural or reinforcing steel, structural column or beam, elevated slab, trusses, or other structural member.
2. Weather-resistant or moisture-resistant elements.

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3. Efficiency, maintenance, or safety of element.
4. Work of others.

C. Refinish surfaces to provide an even finish.

1. Refinish continuous surfaces to nearest intersection.
2. Refinish entire assemblies.
3. Finish restored surfaces to such planes, shapes, and textures that no transition between existing work and the Work is evident in finished surfaces.

D. Restore existing work, Underground Facilities, and surfaces that are to remain in completed Work including concrete-embedded piping, conduit, and other utilities as specified and as shown on Drawings.

E. Make restorations with new materials and appropriate methods as specified for new Work of similar nature; if not specified, use recommended practice of manufacturer or appropriate trade association.

F. Fit Work airtight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces and fill voids.

G. Remove specimens of installed Work for testing when requested by Engineer.

END OF SECTION

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SECTION 01 31 19
PROJECT MEETINGS

PART 1 GENERAL

1.01 GENERAL

A. Engineer will schedule physical arrangements for meetings throughout progress of the Work, prepare meeting agenda with regular participant input and distribute with written notice of each meeting, preside at meetings, record minutes to include significant proceedings and decisions, and reproduce and distribute copies of minutes within 15 days after each meeting to participants and parties affected by meeting decisions.

1.02 PRECONSTRUCTION CONFERENCE

A. Contractor shall be prepared to discuss the following subjects, as a minimum:

1. Required schedules.
2. Status of bonds and insurance.
3. Sequencing of critical path work items.
4. Progress payment procedures.
5. Project changes and clarification procedures.
6. Use of Site, access, office and storage areas, security and temporary facilities.
7. Major product delivery and priorities.
8. Contractor’s safety plan and representative.
9. Status of as-built redline drawings.

B. Attendees will include:

1. Owner’s representatives.
2. Contractor’s office representative.
3. Contractor’s resident superintendent.
4. Contractor’s quality control representative.
5. Subcontractors’ representatives whom Contractor may desire or Engineer may request to attend.
6. Engineer’s representatives.
7. Others as appropriate.

1.03 PRELIMINARY SCHEDULES REVIEW MEETING

A. As set forth in General Conditions and Section 01 32 00, Construction Progress Documentation.

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1.04 PROGRESS MEETINGS

A. Engineer will schedule regular progress meetings at Site, conducted bi-weekly to review the Work progress, Progress Schedule, Schedule of Submittals, Application for Payment, contract modifications, and other matters needing discussion and resolution.

B. Attendees will include:

1. Owner's representative(s), as appropriate.
2. Contractor, Subcontractors, and Suppliers, as appropriate.
3. Engineer's representative(s).
4. Others as appropriate.

1.05 QUALITY CONTROL MEETINGS

A. Scheduled by Engineer on regular basis and as necessary to review test and inspection reports, and other matters relating to quality control of the Work and work of other Contractors.

B. Attendees will include:

1. Contractor.
2. Contractor's designated quality control representative.
3. Subcontractors and Suppliers, as necessary.
4. Engineer's representatives.

1.06 PREINSTALLATION MEETINGS

A. When required in individual Specification sections, convene at Site prior to commencing the Work of that section.

B. Require attendance of entities directly affecting, or affected by, the Work of that section.

C. Notify Engineer 7 days in advance of meeting date.

D. Provide suggested agenda to Engineer to include reviewing conditions of installation, preparation and installation or application procedures, and coordination with related Work and work of others.

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1.07 FACILITY STARTUP MEETINGS

A. Schedule and attend a minimum of two facility startup meetings. The first of such meetings shall be held prior to submitting Facility Startup Plan, as specified in Section 01 91 14, Equipment Testing and Facility Startup, and shall include preliminary discussions regarding such plan.

B. Agenda items shall include, but not be limited to, content of Facility Startup Plan, coordination needed between various parties in attendance, and potential problems associated with startup.

C. Attendees will include:

1. Contractor.
2. Contractor's designated quality control representative.
3. Subcontractors and equipment manufacturer's representatives whom Contractor deems to be directly involved in facility startup.
4. Owner's representative.
5. Engineer's representative.
6. Owner's operations personnel.
7. Others as required by Contract Documents or as deemed necessary by Contractor.

1.08 OTHER MEETINGS

A. In accordance with Contract Documents and as may be required by Owner and Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 32 00
CONSTRUCTION PROGRESS DOCUMENTATION

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Preliminary Progress Schedule: Submit at least 7 days prior to preconstruction conference.
2. Detailed Progress Schedule:
   a. Submit initial Detailed Progress Schedule within 60 days after Effective Date of the Agreement.
   b. Submit an Updated Progress Schedule at each update, in accordance with Article Detailed Progress Schedule.
3. Submit with Each Progress Schedule Submission:
   a. Contractor's certification that Progress Schedule submission is actual schedule being utilized for execution of the Work.
   b. Progress Schedule: Four legible copies.
   c. Narrative Progress Report: Same number of copies as specified for Progress Schedule.
4. Prior to final payment, submit a final Updated Progress Schedule.

1.02 PRELIMINARY PROGRESS SCHEDULE

A. In addition to basic requirements outlined in General Conditions, show a detailed schedule, beginning with Notice to Proceed, for minimum duration of 90 days, and a summary of balance of Project through Final Completion.

B. Show activities including, but not limited to the following:

1. Notice to Proceed.
2. Permits.
3. Submittals, with review time. Contractor may use Schedule of Submittals specified in Section 01 33 00, Submittal Procedures.
4. Early procurement activities for long lead equipment and materials.
5. Initial Site work.
6. Earthwork.
7. Specified Work sequences and construction constraints.
8. Contract Milestone and Completion Dates.
9. Owner-furnished products delivery dates or ranges of dates.
10. Major structural, mechanical, equipment, electrical, architectural, and instrumentation and control Work.

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11. System startup summary.
12. Project close-out summary.
13. Demobilization summary.

C. Update Preliminary Progress Schedule monthly as part of progress payment process. Failure to do so may result in the Owner withholding all or part of the monthly progress payment until the Preliminary Progress Schedule is updated in a manner acceptable to Engineer.

D. Format: In accordance with Article Progress Schedule—Critical Path Network.

1.03 DETAILED PROGRESS SCHEDULE

A. In addition to requirements of General Conditions, submit Detailed Progress Schedule beginning with Notice to Proceed and continuing through Final Completion.

B. Show the duration and sequences of activities required for complete performance of the Work reflecting means and methods chosen by Contractor.

C. When accepted by Engineer, Detailed Progress Schedule will replace Preliminary Progress Schedule and become Baseline Schedule. Subsequent revisions will be considered as Updated Progress Schedules.

D. Format: In accordance with Article Progress Schedule—Critical Path Network.

E. Update monthly to reflect actual progress and occurrences to date, including weather delays.

1.04 PROGRESS SCHEDULE—CRITICAL PATH NETWORK

A. General: Comprehensive computer-generated schedule using Critical Path Method (CPM), generally as outlined in Associated General Contractors of America (AGC) 580, “Construction Project Planning and Scheduling Guidelines.” If a conflict occurs between the AGC publication and this Specification, this Specification shall govern.

B. Contents:

1. Schedule shall begin with the date of Notice to Proceed and conclude with the date of Final Completion.
2. Identify Work calendar basis using days as a unit of measure.

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3. Show complete interdependence and sequence of construction and Project-related activities reasonably required to complete the Work.
4. Identify the Work of separate stages and other logically grouped activities, and clearly identify critical path of activities.
5. Reflect sequences of the Work, restraints, delivery windows, review times, Contract Times and Project Milestones set forth in the Agreement and Section 01 31 13, Project Coordination.
6. Include as applicable, at a minimum:
    a. Obtaining permits, submittals for early product procurement, and long lead time items.
    b. Mobilization and other preliminary activities.
    c. Initial Site work.
    d. Specified Work sequences, constraints, and Milestones, including Substantial Completion date(s) Subcontract Work.
    e. Major equipment design, fabrication, factory testing, and delivery dates.
    f. Delivery dates for Owner-furnished products, as specified in Section 01 11 00, Summary of Work.
    g. Sitework.
    h. Concrete Work.
    i. Structural steel Work.
    j. Architectural features Work.
    k. Conveying systems Work.
    l. Equipment Work.
    m. Mechanical Work.
    n. Electrical Work.
    o. Instrumentation and control Work.
    p. Interfaces with Owner-furnished equipment.
    q. Other important Work for each major facility.
    r. Equipment and system startup and test activities.
    s. Project closeout and cleanup.
    t. Demobilization.
7. No activity duration, exclusive of those for Submittals review and product fabrication/delivery, shall be less than 1 day nor more than 60 days, unless otherwise approved.
8. Activity duration for Submittal review shall not be less than review time specified unless clearly identified and prior written acceptance has been obtained from Engineer.

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C. Schedule Report:

1. On 8-1/2-inch by 11-inch white paper, unless otherwise approved.
2. List information for each activity in tabular format, including at a minimum:
   a. Activity Identification Number.
   b. Activity Description.
   c. Original Duration.
   d. Remaining Duration.
   e. Early Start Date (Actual start on Updated Progress Schedules).
   f. Early Finish Date (Actual finish on Updated Progress Schedules).
   g. Late Start Date.
   h. Late Finish Date.
   i. Total Float.
3. Sort reports as listed activity number sequence with predecessor and successor activity.

1.05 PROGRESS OF THE WORK

A. Updated Progress Schedule shall reflect:

1. Progress of Work to within 5 working days prior to submission.
2. Approved changes in Work scope and activities modified since submission.
3. Delays in Submittals or resubmittals, deliveries, or Work.
4. Adjusted or modified sequences of Work.
5. Other identifiable changes.
6. Revised projections of progress and completion.
7. Report of changed logic.

B. Produce detailed subschedules during Project, upon request of Owner or Engineer, to further define critical portions of the Work such as facility shutdowns.

C. If Contractor fails to complete activity by its latest scheduled completion date and this Failure is anticipated to extend Contract Times (or Milestones), Contractor shall, within 7 days of such failure, submit a written statement as to how Contractor intends to correct nonperformance and return to acceptable current Progress Schedule. Actions by Contractor to complete the Work within Contract Times (or Milestones) will not be justification for adjustment to Contract Price or Contract Times.

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D. Owner may order Contractor to increase plant, equipment, labor force or working hours if Contractor fails to:

1. Complete a Milestone activity by its completion date.
2. Satisfactorily execute Work as necessary to prevent delay to overall completion of Project, at no additional cost to Owner.

1.06 NARRATIVE PROGRESS REPORT

A. Format:

1. Organize same as Progress Schedule.
2. Identify, on a cover letter, reporting period, date submitted, and name of author of report.

B. Contents:

1. Number of days worked over the period, work force on hand, construction equipment on hand (including utility vehicles such as pickup trucks, maintenance vehicles, stake trucks).
2. General progress of Work, including a listing of activities started and completed over the reporting period, mobilization/demobilization of subcontractors, and major milestones achieved.
3. Contractor's plan for management of Site (e.g., lay down and staging areas, construction traffic), utilization of construction equipment, buildup of trade labor, and identification of potential Contract changes.
4. Identification of new activities and sequences as a result of executed Contract changes.
5. Documentation of weather conditions over the reporting period, and any resulting impacts to the work.
6. Description of actual or potential delays, including related causes, and the steps taken or anticipated to mitigate their impact.
7. Changes to activity logic.
8. Changes to the critical path.
9. Identification of, and accompanying reason for, any activities added or deleted since the last report.
10. Steps taken to recover the schedule from Contractor-caused delays.

1.07 SCHEDULE ACCEPTANCE

A. Engineer's acceptance will demonstrate agreement that:

1. Proposed schedule is accepted with respect to:
   a. Contract Times, including Final Completion and all intermediate Milestones are within the specified times.
   b. Specified Work sequences and constraints are shown as specified.

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c. Specified Owner-furnished Equipment or Material arrival dates, or range of dates, are included.
d. Access restrictions are accurately reflected**.**
e. Startup and testing times are as specified.
f. Submittal review times are as specified.

2. In all other respects, Engineer's acceptance of Contractor's schedule indicates that, in Engineer's judgement, schedule represents reasonable plan for constructing Project in accordance with the Contract Documents. Engineer's review will not make any change in Contract requirements. Lack of comment on any aspect of schedule that is not in accordance with the Contract Documents will not thereby indicate acceptance of that change, unless Contractor has explicitly called the nonconformance to Engineer's attention in submittal. Schedule remains Contractor's responsibility and Contractor retains responsibility for performing all activities, for activity durations, and for activity sequences required to construct Project in accordance with the Contract Documents.

B. Unacceptable Preliminary Progress Schedule:

1. Make requested corrections; resubmit within 10 days.
2. Until acceptable to Engineer as Baseline Progress Schedule, continue review and revision process, during which time Contractor shall update schedule on a monthly basis to reflect actual progress and occurrences to date.

C. Unacceptable Detailed Progress Schedule:

1. Make requested corrections; resubmit within 10 days.
2. Until acceptable to Engineer as Baseline Progress Schedule, continue review and revision process.

D. Narrative Report: All changes to activity duration and sequences, including addition or deletion of activities subsequent to Engineer's acceptance of Baseline Progress Schedule, shall be delineated in Narrative Report current with proposed Updated Progress Schedule.

1.08 ADJUSTMENT OF CONTRACT TIMES

A. Reference General Conditions.

B. Evaluation and reconciliation of Adjustments of Contract Times shall be based on the Updated Progress Schedule at the time of proposed adjustment or claimed delay.

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C. Float:

1. Float time is a Project resource available to both parties to meet contract Milestones and Contract Times.
2. Use of float suppression techniques such as preferential sequencing or logic, special lead/lag logic restraints, and extended activity times are prohibited, and use of float time disclosed or implied by use of alternate float-suppression techniques shall be shared to proportionate benefit of Owner and Contractor.
3. Pursuant to above float-sharing requirement, no time extensions will be granted nor delay damages paid until a delay occurs which (i) impacts Project's critical path, (ii) consumes available float or contingency time, and (iii) extends Work beyond contract completion date.

D. Claims Based on Contract Times:

1. Where Engineer has not yet rendered formal decision on Contractor's Claim for adjustment of Contract Times, and parties are unable to agree as to amount of adjustment to be reflected in Progress Schedule, Contractor shall reflect an interim adjustment in the Progress Schedule as acceptable to Engineer.
2. It is understood and agreed that such interim acceptance will not be binding on either Contractor or Owner, and will be made only for the purpose of continuing to schedule Work until such time as formal decision has been rendered as to an adjustment, if any, of the Contract Times.
3. Contractor shall revise Progress Schedule prepared thereafter in accordance with Engineer's formal decision.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 33 00
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 DEFINITIONS

A. Action Submittal: Written and graphic information submitted by Contractor that requires Engineer's approval.

B. Informational Submittal: Information submitted by Contractor that does not require Engineer's approval.

C. Deferred Submittals: Submittals for those portions of the design which are to be submitted to the permitting agency prior to installation of that portion of the work in accordance with IBC Section 106.3.4.2.

1.02 PROCEDURES

A. Direct submittals to Luke Lenard at the following, unless specified otherwise.

Jacobs
Attn: Luke Lenard
401 S. Boston Ave, Suite 330
Tulsa, Oklahoma 74103

B. Location for electronic files transfer will be provided.

C. Transmittal of Submittal:

1. Contractor shall:
   a. Review each submittal and check for compliance with Contract Documents.
   b. Stamp each submittal with uniform approval stamp before submitting to Engineer.
      1) Stamp to include Project name, submittal number, Specification number, Contractor's reviewer name, date of Contractor's approval, and statement certifying submittal has been reviewed, checked, and approved for compliance with Contract Documents.
      2) Engineer will not review submittals that do not bear Contractor's approval stamp and will return them without action.

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2. Complete, sign, and transmit with each submittal package, one Transmittal of Contractor's Submittal form attached at end of this section.
3. Identify each submittal with the following:
   a. Numbering and Tracking System:
      1) Sequentially number each submittal.
      2) Resubmission of submittal shall have original number with sequential alphabetic suffix.
   b. Specification section and paragraph to which submittal applies.
   c. Project title and Engineer's project number.
   d. Date of transmittal.
   e. Names of Contractor, Subcontractor or Supplier, and manufacturer as appropriate.
4. Identify and describe each deviation or variation from Contract Documents.

D. Asset ID Number:

1. All submittals including documents, inspections, testing, etc. shall include the Asset ID Number provided in the inventory table or the Equipment ID number assigned by the City of Tulsa.
2. Documents shall be submitted as separate files for each asset so the documents can be attached to the Lucity records.

E. Format:

1. Do not base Shop Drawings on reproductions of Contract Documents.
2. Package submittal information by individual specification section. Do not combine different specification sections together in submittal package, unless otherwise directed in specification.
3. Present in a clear and thorough manner and in sufficient detail to show kind, size, arrangement, and function of components, materials, and devices, and compliance with Contract Documents.
4. Index with labeled tab dividers in orderly manner.

F. All submittals shall be provided in either 8-1/2 inch by 11 inch or 11 inch by 17 inch PDF format, indexed and shall be provided to the Engineer electronically rather than in paper form. Word and Excel, MathCad and similar files are also acceptable in PDF or live file format where applicable. All correspondence of electronic files shall be submitted by email or Project FTP site.

G. Timeliness: Schedule and submit in accordance Schedule of Submittals, and requirements of individual specification sections.

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H. Processing Time:

1. Time for review shall commence on Engineer's receipt of submittal.
2. Engineer will act upon Contractor's submittal and transmit response to Contractor not later than 30 days after receipt, unless otherwise specified.
3. Resubmittals will be subject to same review time.
4. No adjustment of Contract Times or Price will be allowed as a result of delays in progress of Work caused by rejection and subsequent resubmittals.

I. Resubmittals: Clearly identify each correction or change made.

J. Incomplete Submittals:

1. Engineer will return entire submittal for Contractor's revision if preliminary review deems it incomplete.
2. When any of the following are missing, submittal will be deemed incomplete:
   a. Contractor's review stamp; completed and signed.
   b. Transmittal of Contractor's Submittal; completed and signed.
   c. Insufficient number of copies.

K. Submittals not required by Contract Documents:

1. Will not be reviewed and will be returned stamped "Not Subject to Review."
2. Engineer will keep one copy and return submittal to Contractor.

1.03 ACTION SUBMITTALS

A. Prepare and submit Action Submittals required by individual specification sections.

B. Shop Drawings:

1. One electronic copy indexed.
2. Identify and Indicate:
   a. Applicable Contract Drawing and Detail number, products, units and assemblies, and system or equipment identification or tag numbers.
   b. Equipment and Component Title: Identical to title shown on Drawings.

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c. Critical field dimensions and relationships to other critical features of Work. Note dimensions established by field measurement.
d. Project-specific information drawn accurately to scale.

3. Manufacturer's standard schematic drawings and diagrams as follows:
   a. Modify to delete information that is not applicable to the Work.
   b. Supplement standard information to provide information specifically applicable to the Work.
4. Product Data: Provide as specified in individual specifications.
5. Foreign Manufacturers: When proposed, include the following additional information:
   a. Names and addresses of at least two companies that maintain technical service representatives close to Project.
   b. Complete list of spare parts and accessories for each piece of equipment.

C. Samples:

1. Copies: Three, unless otherwise specified in individual specifications.
2. Preparation:
   a. Mount, display, or package Samples in manner specified to facilitate review of quality. Attach label on unexposed side that includes the following:
      1) Manufacturer name.
      2) Model number.
      3) Material.
      4) Sample source.
3. Manufacturer's Color Chart: Units or sections of units showing full range of colors, textures, and patterns available.
4. Full-size Samples:
   a. Size as indicated in individual specification section.
   b. Prepared from same materials to be used for the Work.
   c. Cured and finished in manner specified.
   d. Physically identical with product proposed for use.

D. Action Submittal Dispositions:

1. Engineer will review, comment, stamp, and distribute as noted:
   a. Approved:
      1) Contractor may incorporate product(s) or implement Work covered by submittal.
      2) Distribution:
         a) One copy furnished Owner.
         b) One copy furnished Resident Project Representative.
         c) One copy retained in Engineer's file.

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d) Remaining copies returned to Contractor appropriately annotated.

2. Approved as Noted:
   a. Contractor may incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
   b. Electronic Distribution:
      1) Owner.
      2) Resident Project Representative.
      3) Engineer.
3. Partial Approval, Resubmit as Noted:
   a. Make corrections or obtain missing portions, and resubmit.
   b. Except for portions indicated, Contractor may begin to incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
   c. Distribution:
      1) Owner.
      2) Resident Project Representative.
      3) Engineer.
4. Revise and Resubmit:
   a. Contractor may not incorporate product(s) or implement Work covered by submittal.
   b. Distribution:
      1) Resident Project Representative.
      2) Engineer.

1.04 INFORMATIONAL SUBMITTALS

A. General:

1. Refer to individual Specification sections for specific submittal requirements.
2. Engineer will review each submittal. If submittal meets conditions of the Contract, Engineer will forward electronic copies to appropriate parties. If Engineer determines submittal does not meet conditions of the Contract and is therefore considered unacceptable, Engineer will respond with review comments to Contractor, and require that submittal be corrected and resubmitted.

B. Deferred Submittals:

1. Deferred submittals contain structural calculations, test results, data sheets (Informational Submittals) and drawings, location sheets, and details (Action Submittals) pertinent to building permitting requirements for systems, components, anchorage, bracing and similar items required by the building code and local jurisdiction or by technical specifications.

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Deferred submittals require manufacturer's or Contractor's design drawings and/or calculations or provide additional design or operational information on life-safety equipment such as fire alarms, smoke alarms, and related systems.

2. All submittals required within Section 01 45 33, Special Inspection, Observation, and Testing, as well as structural calculations, test results, data sheets, and design drawings required by technical sections pertinent to structural design and/or anchorage and/or life safety equipment are by definition, deferred submittals.
3. Coordinate design criteria with criteria provided in technical sections and with criteria provided on the General Structural Note Sheets on the Drawings.
4. Prior to installation of the indicated structural or nonstructural element, equipment, distribution system, or component or its anchorage, the Contractor shall submit the required calculations and supporting data and drawings for review and acceptance by the engineer. Additionally, with acknowledgement of compliance of the project's design criteria indicated on the engineer's comment form, along with the completed submittal, shall then be filed by the Contractor and acknowledged by the permitting agency prior to installation of these items. A list of deferred submittals is contained on Drawings.

C. Application for Payment: In accordance with Section 01 29 00, Payment Procedures.

D. Certificates:

1. General:
   a. Provide notarized statement that includes signature of entity responsible for preparing certification.
   b. Signed by officer or other individual authorized to sign documents on behalf of that entity.
2. Welding: In accordance with individual specification sections.
3. Installer: Prepare written statements on manufacturer's letterhead certifying installer complies with requirements as specified in individual specification section.
4. Material Test: Prepared by qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements.
5. Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in individual specification sections.
6. Manufacturer's Certificate of Compliance: In accordance with Section 01 43 33, Manufacturers' Field Services.

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7. Manufacturer's Certificate of Proper Installation: In accordance with Section 01 43 33, Manufacturers' Field Services.

E. Construction Photographs and Video: In accordance with Section 01 31 13, Project Coordination, and as may otherwise be required in Contract Documents.

F. Contract Closeout Submittals: In accordance with Section 01 77 00, Closeout Procedures.

G. Contractor-design Data (related to temporary construction):

1. Written and graphic information.
2. List of assumptions.
3. List of performance and design criteria.
4. Summary of loads or load diagram, if applicable.
5. Calculations.
6. List of applicable codes and regulations.
7. Name and version of software.
8. Information requested in individual specification section.

H. Manufacturer's Instructions: Written or published information that documents manufacturer's recommendations, guidelines, and procedures in accordance with individual specification section.

I. Operation and Maintenance Data: As required in Section 01 78 23, Operation and Maintenance Data.

J. Schedules:

1. Schedule of Submittals: Prepare separately or in combination with Progress Schedule as specified in Section 01 32 00, Construction Progress Documentation.
   a. Show for each, at a minimum, the following:
      1) Specification section number.
      2) Identification by numbering and tracking system as specified under Paragraph Transmittal of Submittal.
      3) Estimated date of submission to Engineer, including reviewing and processing time.
   b. On a monthly basis, submit updated Schedule of Submittals to Engineer if changes have occurred or resubmittals are required.
2. Schedule of Values: In accordance with Section 01 29 00, Payment Procedures.
3. Schedule of Estimated Progress Payments: In accordance with Section 01 29 00, Payment Procedures.

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4. Progress Schedules: In accordance with Section 01 32 00, Construction Progress Documentation.

K. Special Guarantee: Supplier's written guarantee as required in individual specification sections.

L. Statement of Qualification: Evidence of qualification, certification, or registration as required in Contract Documents to verify qualifications of professional land surveyor, engineer, materials testing laboratory, specialty Subcontractor, trade, Specialist, consultant, installer, and other professionals.

M. Submittals Required by Laws, Regulations, and Governing Agencies:

1. Promptly submit promptly notifications, reports, certifications, payrolls, and otherwise as may be required, directly to the applicable federal, state, or local governing agency or their representative.
2. Transmit to Engineer for Owner's records one copy of correspondence and transmittals (to include enclosures and attachments) between Contractor and governing agency.

N. Test, Evaluation, and Inspection Reports:

1. General: Shall contain signature of person responsible for test or report.
2. Factory:
    a. Identification of product and specification section, type of inspection or test with referenced standard or code.
    b. Date of test, Project title and number, and name and signature of authorized person.
    c. Test results.
    d. If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
    e. Provide interpretation of test results, when requested by Engineer.
    f. Other items as identified in individual specification sections.
3. Field:
    a. As a minimum, include the following:
        1) Project title and number.
        2) Date and time.
        3) Record of temperature and weather conditions.
        4) Identification of product and specification section.
        5) Type and location of test, Sample, or inspection, including referenced standard or code.
        6) Date issued, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.

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7) If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
8) Provide interpretation of test results, when requested by Engineer.
9) Other items as identified in individual specification sections.

O. Testing and Startup Data: In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

P. Training Data: In accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 SUPPLEMENT

A. The supplement listed below, following "End of Section, is part of this Specification.

1. Transmittal of Contractor's Submittal.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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TRANSMITTAL OF CONTRACTOR'S SUBMITTAL

(ATTACH TO EACH SUBMITTAL)

DATE: _____

TO: _____ _____ _____ _____ _____ **FROM**: _____ Contractor _____ _____ _____	Submittal No.: _____ ☐ New Submittal ☐ Resubmittal Project: _____ Project No.: _____ Specification Section No.: _____ **(Cover only one section with each transmittal)** Schedule Date of Submittal: _____

SUBMITTAL TYPE:	☐ Shop Drawing	☐ Sample	☐ Informational
	☐ Deferred		

The following items are hereby submitted:

Number of Copies	Description of Item Submitted (Type, Size, Model Number, Etc.)	Spec. and Para. No.	Drawing or Brochure Number	Contains Variation to Contract	
				No	Yes

Contractor hereby certifies that (i) Contractor has complied with the requirements of Contract Documents in preparation, review, and submission of designated Submittal and (ii) the Submittal is complete and in accordance with the Contract Documents and requirements of laws and regulations and governing agencies.

By: _____
Contractor (Authorized Signature)

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SECTION 01 42 13
ABBREVIATIONS AND ACRONYMS

PART 1 GENERAL

1.01 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 Article 3 of 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, 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.

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1.02 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	APA – The Engineered Wood Association
18.	API	American Petroleum Institute
19.	APWA	American Public Works Association
20.	AHRI	Air-Conditioning, Heating, and Refrigeration Institute
21.	ASA	Acoustical Society of America
22.	ASABE	American Society of Agricultural and Biological Engineers
23.	ASCE	American Society of Civil Engineers
24.	ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
25.	ASME	American Society of Mechanical Engineers
26.	ASNT	American Society for Nondestructive Testing
27.	ASSE	American Society of Sanitary Engineering
28.	ASTM	ASTM International
29.	AWI	Architectural Woodwork Institute
30.	AWPA	American Wood Preservers' Association
31.	AWPI	American Wood Preservers' Institute
32.	AWS	American Welding Society
33.	AWWA	American Water Works Association

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34.	BHMA	Builders Hardware Manufacturers' Association
35.	CBM	Certified Ballast Manufacturer
36.	CDA	Copper Development Association
37.	CGA	Compressed Gas Association
38.	CISPI	Cast Iron Soil Pipe Institute
39.	CMAA	Crane Manufacturers' Association of America
40.	CRSI	Concrete Reinforcing Steel Institute
41.	CS	Commercial Standard
42.	CSA	Canadian Standards Association
43.	CSI	Construction Specifications Institute
44.	DIN	Deutsches Institut für Normung e.V.
45.	DIPRA	Ductile Iron Pipe Research Association
46.	EIA	Electronic Industries Alliance
47.	EJCDC	Engineers Joint Contract Documents' Committee
48.	ETL	Electrical Test Laboratories
49.	FAA	Federal Aviation Administration
50.	FCC	Federal Communications Commission
51.	FDA	Food and Drug Administration
52.	FEMA	Federal Emergency Management Agency
53.	FIPS	Federal Information Processing Standards
54.	FM	FM Global
55.	Fed. Spec.	Federal Specifications (FAA Specifications)
56.	FS	Federal Specifications and Standards (Technical Specifications)
57.	GA	Gypsum Association
58.	GANA	Glass Association of North America
59.	HI	Hydraulic Institute
60.	HMI	Hoist Manufacturers' Institute
61.	IBC	International Building Code
62.	ICBO	International Conference of Building Officials
63.	ICC	International Code Council
64.	ICEA	Insulated Cable Engineers' Association
65.	IFC	International Fire Code
66.	IEEE	Institute of Electrical and Electronics Engineers, Inc.
67.	IESNA	Illuminating Engineering Society of North America
68.	IFI	Industrial Fasteners Institute
69.	IGMA	Insulating Glass Manufacturer's Alliance
70.	IMC	International Mechanical Code
71.	INDA	Association of the Nonwoven Fabrics Industry
72.	IPC	International Plumbing Code
73.	ISA	International Society of Automation

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74.	ISO	International Organization for Standardization
75.	ITL	Independent Testing Laboratory
76.	JIC	Joint Industry Conferences of Hydraulic Manufacturers
77.	MIA	Marble Institute of America
78.	MIL	Military Specifications
79.	MMA	Monorail Manufacturers' Association
80.	MSS	Manufacturer's Standardization Society
81.	NAAMM	National Association of Architectural Metal Manufacturers
82.	NACE	NACE International
83.	NBGQA	National Building Granite Quarries Association
84.	NEBB	National Environmental Balancing Bureau
85.	NEC	National Electrical Code
86.	NECA	National Electrical Contractor's Association
87.	NEMA	National Electrical Manufacturers' Association
88.	NESC	National Electrical Safety Code
89.	NETA	InterNational Electrical Testing Association
90.	NFPA	National Fire Protection Association
91.	NHLA	National Hardwood Lumber Association
92.	NICET	National Institute for Certification in Engineering Technologies
93.	NIST	National Institute of Standards and Technology
94.	NRCA	National Roofing Contractors Association
95.	NRTL	Nationally Recognized Testing Laboratories
96.	NSF	NSF International
97.	NSPE	National Society of Professional Engineers
98.	NTMA	National Terrazzo and Mosaic Association
99.	NWWDA	National Wood Window and Door Association
100.	OSHA	Occupational Safety and Health Act (both Federal and State)
101.	PCI	Precast/Prestressed Concrete Institute
102.	PEI	Porcelain Enamel Institute
103.	PPI	Plastic Pipe Institute
104.	PS	Product Standards Section-U.S. Department of Commerce
105.	RMA	Rubber Manufacturers' Association
106.	RUS	Rural Utilities Service
107.	SAE	SAE International
108.	SDI	Steel Deck Institute
109.	SDI	Steel Door Institute
110.	SJI	Steel Joist Institute
111.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association

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112.	SPI	Society of the Plastics Industry
113.	SSPC	The Society for Protective Coatings
114.	STI/SPFA	Steel Tank Institute/Steel Plate Fabricators Association
115.	SWI	Steel Window Institute
116.	TEMA	Tubular Exchanger Manufacturers' Association
117.	TCA	Tile Council of North America
118.	TIA	Telecommunications Industry Association
119.	UBC	Uniform Building Code
120.	UFC	Uniform Fire Code
121.	UL	Underwriters Laboratories Inc.
122.	UMC	Uniform Mechanical Code
123.	USBR	U.S. Bureau of Reclamation
124.	WCLIB	West Coast Lumber Inspection Bureau
125.	WI	Wood Institute
126.	WWPA	Western Wood Products Association

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 01 43 33
MANUFACTURERS' FIELD SERVICES

PART 1 GENERAL

1.01 DEFINITIONS

A. Person-Day: One person for 8 hours within regular Contractor working hours.

1.02 SUBMITTALS

A. Informational Submittals:

1. Training Schedule: Submit, in accordance with requirements of this Specification, not less than 21 days prior to start of equipment installation and revise as necessary for acceptance.
2. Lesson Plan: Submit, in accordance with requirements of this Specification, proposed lesson plan not less than 21 days prior to scheduled training and revise as necessary for acceptance.
3. Training Session Recordings: Furnish Owner with two complete sets of DVDs fully indexed and cataloged with printed label stating session and date recorded.

1.03 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer to issue the certifications required of the manufacturer. Additional qualifications may be specified in the individual specification section.

B. Representative subject to acceptance by Owner and Engineer. No substitute representatives will be allowed unless prior written approval by such has been given.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

A. Furnish manufacturers' services, when required by an individual specification section, to meet the requirements of this section.

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B. Where time is necessary in excess of that stated in the Specifications for manufacturers' services, or when a minimum time is not specified, time required to perform specified services shall be considered incidental.

C. Schedule manufacturer' services to avoid conflict with other onsite testing or other manufacturers' onsite services.

D. Determine, before scheduling services, that conditions necessary to allow successful testing have been met.

E. Only those days of service approved by Engineer will be credited to fulfill specified minimum services.

F. When specified in individual specification sections, manufacturer's onsite services shall include:

1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
3. Providing, on a daily basis, copies of manufacturers' representatives field notes and data to Engineer.
4. Revisiting the Site as required to correct problems and until installation and operation are acceptable to Engineer.
5. Resolution of assembly or installation problems attributable to or associated with respective manufacturer's products and systems.
6. Assistance during functional and performance testing, and facility startup and evaluation.
7. Training of Owner's personnel in the operation and maintenance of respective product as required.
8. Additional requirements may be specified elsewhere.

3.02 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

A. When so specified, a Manufacturer's Certificate of Compliance, a copy of which is attached to this section, shall be completed in full, signed by entity supplying the product, material, or service, and submitted prior to shipment of product or material or execution of the services.

B. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.

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C. Such form shall certify proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.

D. May reflect recent or previous test results on material or product, if acceptable to Engineer.

3.03 MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

A. When so specified, a Manufacturer's Certificate of Proper Installation form, a copy of which is attached to this section, shall be completed and signed by equipment manufacturer's representative.

B. Such form shall certify signing party is a duly authorized representative of manufacturer, is empowered by manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to ensure equipment is complete and operational.

3.04 TRAINING

A. General:

1. Furnish manufacturers' representatives for detailed classroom and hands-on training to Owner's personnel on operation and maintenance of specified product (system, subsystem, component) and as may be required in applicable Specifications.
2. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with Owner, and familiar with operation and maintenance manual information specified in Section 01 78 23, Operation and Maintenance Data.
3. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
4. Furnish complete training materials, to include operation and maintenance data, to be retained by each trainee.

B. Training Schedule:

1. List specified equipment and systems that require training services and show:
   a. Respective manufacturer.
   b. Estimated dates for installation completion.
   c. Estimated training dates.
2. Allow for multiple sessions when several shifts are involved.
3. Adjust schedule to ensure training of appropriate personnel as deemed necessary by Owner, and to allow full participation by manufacturers'

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representatives. Adjust schedule for interruptions in operability of equipment.

4. Coordinate with Section 01 32 00, Construction Progress Documentation, and Section 01 91 14, Equipment Testing and Facility Startup.

C. Lesson Plan:

1. When manufacturer or vendor training of Owner personnel is specified, prepare a lesson plan for each required course containing the following minimum information:
   a. Title and objectives.
   b. Recommended attendees (such as, managers, engineers, operators, maintenance).
   c. Course description, outline of course content, and estimated class duration.
   d. Format (such as, lecture, self-study, demonstration, hands-on).
   e. Instruction materials and equipment requirements.
   f. Resumes of instructors providing training.

D. Prestartup Training:

1. Coordinate training sessions with Owner's operating personnel and manufacturers' representatives, and with submission of operation and maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Data.
2. Complete at least 14 days prior to beginning of facility startup.

E. Post-startup Training: If required in Specifications, furnish and coordinate training of Owner's operating personnel by respective manufacturer's representatives.

F. Recording of Training Sessions:

1. Furnish digital records of prestartup and post-startup instruction sessions, including manufacturers' representatives' hands-on equipment instruction and classroom sessions.
2. DVDs shall be produced by a qualified, professional video production company.
3. Use format suitable for playback on standard equipment available commercially in the United States.
4. Include one training session on each DVD.

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3.05 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are part of this Specification.

1. Manufacturer’s Certificate of Compliance.
2. Manufacturer’s Certificate of Proper Installation.

END OF SECTION

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MANUFACTURER'S CERTIFICATE OF COMPLIANCE

OWNER: _____

PROJECT NAME: _____

PROJECT NO: _____

PRODUCT, MATERIAL, OR SERVICE SUBMITTED: _____

Comments: _____

_____

_____

_____

_____

_____

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the Contract requirements, and are in the quantity shown.

Date of Execution: _____, 20___

Manufacturer: _____

Manufacturer's Authorized Representative *(print)*: _____

_____

(Authorized Signature)

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MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

OWNER _____ EQPT SERIAL NO: _____

EQPT TAG NO: _____ EQPT/SYSTEM: _____

PROJECT NO: _____ SPEC. SECTION: _____

I hereby certify that the above-referenced equipment/system has been:

(Check Applicable)

☐ Installed in accordance with Manufacturer's recommendations.

☐ Inspected, checked, and adjusted.

☐ Serviced with proper initial lubricants.

☐ Electrical and mechanical connections meet quality and safety standards.

☐ All applicable safety equipment has been properly installed.

☐ Functional tests.

☐ System has been performance tested, and meets or exceeds specified performance requirements. (When complete system of one manufacturer)

Note: Attach any performance test documentation from manufacturer.

Comments: _____

_____

_____

_____

I, the undersigned Manufacturer's Representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate their equipment and (iii) authorized to make recommendations required to ensure equipment furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____, 20___

Manufacturer:_____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)

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SECTION 01 45 16.13
CONTRACTOR QUALITY CONTROL

PART 1 GENERAL

1.01 DEFINITIONS

A. Contractor Quality Control (CQC): The means by which Contractor ensures that the construction, to include that performed by subcontractors and suppliers, complies with the requirements of the Contract.

1.02 SUBMITTALS

A. Informational Submittals:

1. CQC Plan: Submit, not later than 30 days after receipt of Notice to Proceed.
2. CQC Report: Submit, weekly, an original and one copy in report form.

1.03 OWNER'S QUALITY ASSURANCE

A. All Work is subject to Owner's quality assurance inspection and testing at all locations and at all reasonable times before acceptance to ensure strict compliance with the terms of the Contract Documents.

B. Owner's quality assurance inspections and tests are for the sole benefit of Owner and do not:

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

C. The presence or absence of a quality assurance inspector does not relieve Contractor from any Contract requirement.

D. Promptly furnish all facilities, labor, and material reasonably needed for performing such safe and convenient inspections and tests as may be required by Engineer.

E. Owner may charge Contractor for any additional cost of inspection or test when Work is not ready at the time specified by Contractor for inspection or

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test, or when prior rejection makes re-inspection or retest necessary. Quality assurance inspections and tests will be performed in a manner that will not unnecessarily delay the Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Maintain an adequate inspection system and perform such inspections as will ensure that the Work conforms to the Contract Documents.

B. Maintain complete inspection records and make them available at all times to Owner and Engineer.

C. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product that complies with the Contract Documents. The system shall cover all construction and demolition operations, both onsite and offsite, including Work by subcontractors, fabricators, suppliers and purchasing agents, and shall be keyed to the proposed construction sequence.

3.02 COORDINATION MEETING

A. After the Preconstruction Conference, but before start of construction, and prior to acceptance of the CQC Plan, schedule a meeting with Engineer and Owner to discuss the quality control system.

B. Develop a mutual understanding of the system details, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite Work, and the interrelationship of Contractor’s management and control with the Owner’s Quality Assurance.

C. There may be occasions when subsequent conferences may be called by either party to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures that may require corrective action by Contractor.

3.03 QUALITY CONTROL ORGANIZATION

A. CQC System Manager:

1. Designate an individual within Contractor’s organization who will be responsible for overall management of CQC and have the authority to act in CQC matters for the Contractor.

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2. CQC System Manager may perform other duties on the Project.
3. CQC System Manager shall be an experienced construction person, with a minimum of 3 years construction experience on similar type Work.
4. CQC System Manager shall report to the Contractor's project manager or someone higher in the organization. Project manager in this context shall mean the individual with responsibility for the overall quality and production management of the Project.
5. CQC System Manager shall be onsite during construction; periods of absence may not exceed 2 weeks at any one time.
6. Identify an alternate for CQC System Manager to serve with full authority during the System Manager's absence. The requirements for the alternate will be the same as for designated CQC System Manager.

B. CQC Staff:

1. Designate a CQC staff, available at the Site at all times during progress, with complete authority to take any action necessary to ensure compliance with the Contract. CQC staff members shall be subject to acceptance by Engineer.
2. CQC staff shall take direction from CQC System Manager in matters pertaining to QC.
3. CQC staff must be of sufficient size to ensure adequate QC coverage of Work phases, work shifts, and work crews involved in the construction. These personnel may perform other duties, but must be fully qualified by experience and technical training to perform their assigned QC responsibilities and must be allowed sufficient time to carry out these responsibilities.
4. The actual strength of the CQC staff may vary during any specific Work period to cover the needs of the Project. Add additional staff when necessary for a proper CQC organization.

C. Organizational Changes: Obtain Engineer's acceptance before replacing any member of the CQC staff. Requests for changes shall include name, qualifications, duties, and responsibilities of the proposed replacement.

3.04 QUALITY CONTROL PHASING

A. CQC shall include at least three phases of control to be conducted by CQC System Manager for all definable features of Work, as follows:

1. Preparatory Phase:
   a. Notify Owner at least 48 hours in advance of beginning any of the required action of the preparatory phase.

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b. This phase shall include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. The CQC System Manager shall instruct applicable CQC staff as to the acceptable level of workmanship required in order to meet Contract requirements.
c. Document the results of the preparatory phase meeting by separate minutes prepared by the CQC System Manager and attached to the QC report.
d. Perform prior to beginning Work on each definable feature of Work:
    1) Review applicable Contract Specifications.
    2) Review applicable Contract Drawings.
    3) Verify that all materials and/or equipment have been tested, submitted, and approved.
    4) Verify that provisions have been made to provide required control inspection and testing.
    5) Examine the Work area to verify that all required preliminary Work has been completed and is in compliance with the Contract.
    6) Perform a physical examination of required materials, equipment, and sample Work to verify that they are on hand, conform to approved Shop Drawing or submitted data, and are properly stored.
    7) Review the appropriate activity hazard analysis to verify safety requirements are met.
    8) Review procedures for constructing the Work, including repetitive deficiencies.
    9) Document construction tolerances and workmanship standards for that phase of the Work.
    10) Check to verify that the plan for the Work to be performed, if so required, has been accepted by Engineer.

2. Initial Phase:
    a. Accomplish at the beginning of a definable feature of Work:
        1) Notify Owner at least 48 hours in advance of beginning the initial phase.
        2) Perform prior to beginning Work on each definable feature of Work:
            a) Review minutes of the preparatory meeting.
            b) Check preliminary Work to verify compliance with Contract requirements.
            c) Verify required control inspection and testing.

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d) Establish level of workmanship and verify that it meets minimum acceptable workmanship standards. Comparison with sample panels is appropriate.
e) Resolve all differences.
f) Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.

3) Separate minutes of this phase shall be prepared by the CQC System Manager and attached to the QC report. Exact location of initial phase shall be indicated for future reference and comparison with follow-up phases.
4) The initial phase should be repeated for each new crew to work onsite, or any time acceptable specified quality standards are not being met.

3. Follow-up Phase:
   a. Perform daily checks to verify continuing compliance with Contract requirements, including control testing, until completion of the particular feature of Work.
   b. Daily checks shall be made a matter of record in the CQC documentation and shall document specific results of inspections for all features of Work for the day or shift.
   c. Conduct final follow-up checks and correct all deficiencies prior to the start of additional features of Work that will be affected by the deficient Work. Constructing upon or concealing nonconforming Work will not be allowed.
4. Additional Preparatory and Initial Phases: Additional preparatory and initial phases may be conducted on the same definable features of Work as determined by Owner if the quality of ongoing Work is unacceptable; or if there are changes in the applicable QC staff or in the onsite production supervision or work crew; or if work on a definable feature is resumed after a substantial period of inactivity, or if other problems develop.

3.05 CONTRACTOR QUALITY CONTROL PLAN

A. General:

1. Plan shall identify personnel, procedures, control, instructions, test, records, and forms to be used.
2. An interim plan for the first 30 days of operation will be considered.
3. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of Work to be started.

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4. Work outside of the features of Work included in an accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or another interim plan containing the additional features of Work to be started.

B. Content:

1. Plan shall cover the intended CQC organization for the entire Contract and shall include the following, as a minimum:
   a. Organization: Description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff will implement the three-phase control system (see Paragraph QC Phasing) for all aspects of the Work specified.
   b. CQC Staff: The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a QC function.
   c. Letters of Authority: A copy of a letter to the CQC System Manager signed by an authorized official of the firm, describing the responsibilities and delegating sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop Work which is not in compliance with the Contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities and responsibilities. Copies of these letters will also be furnished to Owner.
   d. Submittals: Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers and purchasing agents.
   e. Testing: Control, verification and acceptance testing procedures for each specific test to include the test name, frequency, specification paragraph containing the test requirements, the personnel and laboratory responsible for each type of test, and an estimate of the number of tests required.
   f. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests, including documentation.
   g. Procedures for tracking deficiencies from identification through acceptable corrective action. These procedures will establish verification that identified deficiencies have been corrected.
   h. Reporting procedures, including proposed reporting formats; include a copy of the CQC report form.

C. Acceptance of Plans: Acceptance of the Contractor’s basic and addendum CQC plans is required prior to the start of construction. Acceptance is

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conditional and will be predicated on satisfactory performance during the construction. Owner reserves the right to require Contractor to make changes in the CQC plan and operations including removal of personnel, as necessary, to obtain the quality specified.

D. Notification of Changes: After acceptance of the CQC plan, Contractor shall notify Engineer, in writing, a minimum of 7 calendar days prior to any proposed change. Proposed changes are subject to acceptance by Engineer.

3.06 CONTRACTOR QUALITY CONTROL REPORT

A. As a minimum, prepare a CQC report for every 7 calendar days. Account for all days throughout the life of the Contract. Reports shall be signed and dated by CQC System Manager. Include copies of test reports and copies of reports prepared by QC staff.

B. Maintain current records of quality control operations, activities, and tests performed, including the Work of subcontractors and suppliers.

C. Records shall be on an acceptable form and shall be a complete description of inspections, the results of inspections, daily activities, tests, and other items, including but not limited to the following:

1. Contractor/subcontractor and their areas of responsibility.
2. Operating plant/equipment with hours worked, idle, or down for repair.
3. Work performed today, giving location, description, and by whom. When a network schedule is used, identify each phase of Work performed each day by activity number.
4. Test and/or control activities performed with results and references to specifications/plan requirements. The control phase should be identified (Preparatory, Initial, Follow-up). List deficiencies noted along with corrective action.
5. Material received with statement as to its acceptability and storage.
6. Identify submittals reviewed, with Contract reference, by whom, and action taken.
7. Offsite surveillance activities, including actions taken.
8. Job safety evaluations stating what was checked, results, and instructions or corrective actions.
9. List instructions given/received and conflicts in Drawings and/or Specifications.
10. Contractor’s verification statement.
11. Indicate a description of trades working on the Project; the number of personnel working; weather conditions encountered; and any delays encountered.

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12. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in file work and workmanship comply with the Contract.

3.07 SUBMITTAL QUALITY CONTROL

A. Submittals shall be as specified in Section 01 33 00, Submittal Procedures. The CQC organization shall be responsible for certifying that all submittals are in compliance with the Contract requirements. Owner will furnish copies of test report forms upon request by Contractor. Contractor may use other forms as approved.

3.08 TESTING QUALITY CONTROL

A. Testing Procedure:

1. Perform tests specified or required to verify that control measures are adequate to provide a product which conforms to Contract requirements. Perform the following activities and record the following data:
   a. Verify testing procedures comply with contract requirements.
   b. Verify facilities and testing equipment are available and comply with testing standards.
   c. Check test instrument calibration data against certified standards.
   d. Verify recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.
   e. Documentation:
      1) Record results of all tests taken, both passing and failing, on the CQC report for the date taken.
      2) Include specification paragraph reference, location where tests were taken, and the sequential control number identifying the test.
      3) Actual test reports may be submitted later, if approved by Engineer, with a reference to the test number and date taken.
      4) Provide directly to Engineer an information copy of tests performed by an offsite or commercial test facility. Test results shall be signed by an engineer registered in the state where the tests are performed.
      5) Failure to submit timely test reports, as stated, may result in nonpayment for related Work performed and disapproval of the test facility for this Contract.

B. Testing Laboratories: Laboratory facilities, including personnel and equipment, utilized for testing soils, concrete, asphalt and steel shall meet

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criteria detailed in ASTM D3740 and ASTM E329, and be accredited by the American Association of Laboratory Accreditation (AALA), National Institute of Standards and Technology (NIST), National Voluntary Laboratory Accreditation Program (NVLAP), the American Association of State Highway and Transportation Officials (AASHTO), or other approved national accreditation authority. Personnel performing concrete testing shall be certified by the American Concrete Institute (ACI).

3.09 COMPLETION INSPECTION

A. CQC System Manager shall conduct an inspection of the Work at the completion of all Work or any milestone established by a completion time stated in the Contract.

B. Punchlist:

1. CQC System Manager shall develop a punchlist of items which do not conform to the Contract requirements.
2. Include punchlist in the CQC report, indicating the estimated date by which the deficiencies will be corrected.
3. CQC System Manager or staff shall make a second inspection to ascertain that all deficiencies have been corrected and so notify the Owner.
4. These inspections and any deficiency corrections required will be accomplished within the time stated for completion of the entire Work or any particular increment thereof if the Project is divided into increments by separate completion dates.

END OF SECTION

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SECTION 01 45 33
SPECIAL INSPECTION, OBSERVATION, AND TESTING

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for Special Inspection, Observation, and Testing required in accordance with Chapter 17 of the 2018 IBC and is in addition to and supplements requirements included in Statement of Special Inspections shown on Drawings.

1.02 REFERENCES

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

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

1.03 DEFINITIONS

A. Agencies and Personnel:

1. Agency Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.
2. Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved.
3. Registered Design Professional in Responsible Charge: An individual who is registered or licensed to practice their respective design profession as defined by statutory requirements of professional registration laws of state or jurisdiction in which Project is to be constructed.
4. Special Inspector: Qualified person employed by Owner who will demonstrate competence to the satisfaction of AHJ for inspection of a particular type of construction or operation requiring Special Inspection.

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B. Statement of Special Inspections: Detailed written procedure contained on Drawings establishing systems and components subject to Special Inspection, Observation, and Testing during construction, type and frequency of testing, extent and duration of Special Inspection, and reports to be completed and distributed by Special Inspector.

C. Special Inspection:

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

D. Nonstructural Components:

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

E. Professional Observation:

1. Does not include or waive responsibility for required Special Inspection or inspections by building official.
2. Requirements are indicated on Statement of Special Inspections provided on Drawings.
3. Geotechnical Observation: Visual observation of selected subgrade bearing surfaces and installation of deep foundation elements by a registered design professional for general conformance to Contract Documents.

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4. Structural Observation: Visual observation of structural system(s) by a registered design professional for general conformance to Contract Documents.

1.04 STATEMENT OF SPECIAL INSPECTIONS REQUIREMENTS

A. Designated Systems for Inspection:

1. Seismic-force-resisting systems designated under IBC Section 1705 and subject to Special Inspection under Section 1705: None required.
2. Wind-force-resisting systems designated under IBC Section 1705: None required.
3. Architectural, Plumbing, Mechanical, and Electrical Components subject to Special Inspection under IBC Section 1705.12.5 and Section 1705.12.6 for Seismic Resistance: None required.

B. Statement of Special Inspections:

1. As included on Drawings and in support of building permit application, Project-specific requirements were prepared by Registered Design Professional in Responsible Charge. The following identifies elements of inspection, observation, and testing program to be followed in construction of the Work:
   a. Special Inspection and testing required by IBC Section 1705 and other applicable sections and referenced standards therein.
   b. Type and frequency of Special Inspection required.
   c. Type and frequency of testing required.
   d. Required frequency and distribution of testing and Special Inspection reports to be distributed by Special Inspector to Engineer, Contractor, building official, and Owner.
   e. Geotechnical Observation to be Performed: Required frequency and distribution of Geotechnical Observation reports by registered design professional to Contractor, building official, and Owner. Structural Observations to be Performed: Required frequency and distribution of Structural Observation reports by registered design professional to Contractor, building official, and Owner.

C. Special Inspection and associated testing of shop fabrication and field construction will be performed by an approved accredited independent agency or by Authority Having Jurisdiction’s (AHJ) approved, qualified inspection staff. Owner will secure and pay for services of agency to perform Special Inspection and associated testing.

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D. Code required Special Inspection with associated testing and Professional Observation, as provided in Statement of Special Inspections on Drawings and further provided in this section, is for benefit of Owner and does not:

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

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

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

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

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Requirements of the Statement of Special Inspections are provided by the Owner. All other testing and inspections, unless noted otherwise, are provided by Contractor.

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

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

D. Provide access for Special Inspector to construction documents.

E. Retain special inspection records on-site to be readily available for review.

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F. Cooperate with Special Inspector and provide safe access to the Work to be inspected.

G. Provide reasonable auxiliary services as requested by the Special Inspector. Auxiliary services required include, but not limited to:

1. Providing access to the Work and furnishing incidental labor and facilities necessary to facilitate inspections and tests to assist the Special Inspector in performing test/inspections.
2. Providing storage space for the Special Inspector's exclusive use, such as for storing and curing concrete test samples and delivery of samples to testing laboratories.
3. Providing the Special Inspector with access to all approved submittals.
4. Providing security and protection of samples and test equipment at the Project Site.
5. Provide samples of materials to be tested in required quantities.

H. Materials and systems shall be inspected during placement where Continuous Special Inspection is required.

I. Where Periodic Special Inspection is indicated in the Statement of Special Inspections:

1. Schedule inspections for either during or at completion of their placement or a combination or both.
2. Schedule periodically inspected Work (either inspected during or after its placement) so that corrections can be completed and re-inspected before Work is inaccessible.
3. Sampling a portion of the Work is not allowed. Schedules shall provide for inspection of all Work requiring periodic inspection.

END OF SECTION

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SECTION 01 50 00
TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Nursery and Landscape Association (ANLA): American Standards for Nursery Stock.
2. Federal Emergency Management Agency (FEMA).
3. National Fire Prevention Association (NFPA): 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations.
4. Telecommunications Industry Association (TIA): 568-C, Commercial Building Telecommunications Cabling Standard.
5. U.S. Department of Agriculture (USDA): Urban Hydrology for Small Watersheds.
6. U.S. Weather Bureau: Rainfall-Frequency Atlas of the U.S. for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years.

1.02 SUBMITTALS

A. Informational Submittals:

1. Copies of permits and approvals for construction as required by Laws and Regulations and governing agencies.
2. Temporary Utility Submittals:
   a. Electric power supply and distribution plans.
   b. Water supply and distribution plans.
   c. Sanitary.
3. Temporary Construction Submittals:
   a. Access Roads: Routes.
   b. Parking area plans.
   c. Contractor’s field office, storage yard, and storage building plans, including gravel surfaced area.
   d. Fencing and protective barrier locations and details.
   e. Engineer’s field office plans.
   f. Staging area location plan.

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1.03 MOBILIZATION

A. Mobilization shall include, but not be limited to, these principal items:

1. Obtaining required permits.
2. Moving Contractor's field office and equipment required for first month operations onto Site.
3. Installing temporary construction power, wiring, and lighting facilities.
4. Providing onsite communication facilities, including telephones.
5. Providing onsite sanitary facilities and potable water facilities as specified and as required by Laws and Regulations, and governing agencies.
6. Arranging for and erection of Contractor's work and storage yard.
7. Posting OSHA required notices and establishing safety programs and procedures.
8. Having Contractor's superintendent at Site full time.

B. Use area designated for Contractor's temporary facilities as shown on Drawings.

1.04 PROTECTION OF WORK AND PROPERTY

A. Comply with Owner's safety rules while on Owner's property.

B. Keep Owner informed of serious onsite accidents and related claims.

C. Use of Explosives: No blasting or use of explosives will be allowed onsite.

1.05 VEHICULAR TRAFFIC

A. Traffic Control Plan: Adhere to traffic control plan reviewed and accepted by Engineer. Changes to this plan shall be made only by written approval of Engineer. Secure approvals for necessary changes so as not to delay progress of the Work. The Traffic Control Plan shall adhere to the Manual Uniform Traffic Control Device (MUTCD), latest edition.

B. Maintain traffic flow on all water plant roads. Some roads may be closed temporarily when construction operations require excavation, as approved in the Traffic Control Plan. However, no road closures are anticipated to be required.

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PART 2 PRODUCTS

2.01 ENGINEER'S FIELD OFFICES

A. Furnish equipment specified for exclusive use of Engineer and its representatives.

B. Ownership of equipment furnished under this article will remain, unless otherwise specified, that of Contractor.

C. Equipment furnished shall be new or like new in appearance and function.

D. Minimum Features:

1. 110-volt lighting and wall plugs.
2. Fluorescent ceiling lights.
3. Electric heating and self-contained air conditioning unit, properly sized for Project locale and conditions. Provide ample electric power to operate installed systems.
4. Railed stairways and landings at entrances.
5. Sign on entrance door reading JACOBS, letter height 4 inches minimum.
6. Exterior Door(s):
   a. Number: Two.
   b. Type: Solid core.
   c. Lock(s): Cylindrical; keyed alike.
7. Number of Windows: Seven.
8. Minimum Interior Height: 8 feet.

E. Trailer Type Mobile Structure: One.

F. Floor Space: Minimum 660 square feet.

G. All-metal frame; all-metal exterior, sides, and roof; and insulated double walls, floor, and roof.

H. Security guard screens on all windows.

I. Toilet and wash basin in separate compartment with hot and cold water and drains.

J. Number of Private Offices: One, 10 feet by 16 feet.

K. Storage Room: One, 6 feet by 8 feet, with door with cylinder lock, keyed differently than exterior door locks. Provide three sets of keys.

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L. Shelving in Storage Room: 72 linear feet, 18 inches deep.

M. Blinds on all windows.

N. Work Surface: One, 30 inches by 10 feet at desk height of 29 inches from floor.

O. Office Equipment—General:

1. Bottled Water Service: One, with cooler capable of producing hot water and cold water.
2. Paper Cup Dispenser with Cups: One.
3. Paper Towel Dispenser with Towels: One.
4. Desk: One, steel, 30 inches by 60 inches with desk surface located 29 inches from floor.
5. Desk Chair: One, Aeron Chair by Herman Miller, with the following characteristics:
   a. Five castor base.
   b. Adjustable height.
   c. Swivels.
   d. Locking Back.
   e. Adjustable seat back for height and angle.
   f. Adjustable arms.
   g. Zonal back support.
   h. Tilt limiter with seat angle adjustment.
   i. Mini-refrigerator.
   j. Microwave.
6. Folding Table: Two, 36 inches by 72 inches.
7. Steel Folding Chairs: Twelve.
8. Drafting Table: One, 3 feet by 6 feet.
9. Drafting Stool: One.
10. Four-Drawer Steel File with Lock: One, legal width.
11. Drawing Rack with Drawing Hangers: Two.
12. Bookcase: Two, 36 inches wide by 48 inches high.
13. Wastepaper Basket: Three.
14. Digital camera EOS Rebel T5 DSLR with 18 mm to 55 mm and 75 mm to 300 mm lenses with carrying case; “or-equal.”
15. Clothes Rack: One.
16. First-Aid Kit: One.
17. Tri-Class (ABC), Dry Chemical Fire Extinguisher, 10-Pound: One.
18. Duplicator, dry type, self-feeding, capable of providing 11-inch by 17-inch, 8-1/2-inch by 11-inch, and 8-1/2-inch by 14-inch copies and collating multiple copies to 10, and reduction and enlargement

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capabilities, color printing and color scanning capabilities; include maintenance service agreement for duration of contract.

2.02 PROJECT SIGN

A. Provide and maintain one project signed per City of Tulsa Standard No. 102.

PART 3 EXECUTION

3.01 ENGINEER'S FIELD OFFICE

A. Make available for Engineer's use prior to start of the Work at Site and to remain on Site for minimum of 30 days after final acceptance of the Work.

B. Locate where directed by Engineer; level, block, tie down, skirt, provide stairways, and relocate when necessary and approved. Construct on proper foundations, and provide proper surface drainage and connections for utility services.

C. Provide minimum 100 square feet of gravel or crushed rock base, minimum depth of 4 inches, at each entrance.

D. Raise grade under field office, as necessary, to elevation adequate to avoid flooding.

E. Provide sanitary facilities in compliance with state and local health authorities.

F. Exterior Door Keys: Furnish two set(s) of keys.

G. Computer:

1. Provide required connecting cables and plugs.
2. Provide two 22-inch monitors with adjustable stands, Dell 22 Monitor P2217H; "or-equal."
3. Provide two lap top stands.
4. Provide two wireless keyboards and mice.
5. One tetrabyte backup hard drive.

H. Telecommunications:

1. Provide DSL internet connection with minimum of five live portable computer (PC) ports.
2. Provide appropriate jacks, CAT-5 patch cords, wiring, and equipment required for a complete telecommunications system.

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3. Arrange and provide for telecommunication service for use during construction. Pay costs of installation, maintenance, and monthly service of internet connection.

I. Maintain in good repair and appearance, and provide weekly professional cleaning service and replenishment, as required, of paper towels, paper cups, hand soap, toilet paper, first-aid kit supplies, and bottled water.

J. Replenish, as needed, duplicator/printer paper and toner, rewritable compact disks/DVDs.

3.02 TEMPORARY UTILITIES

A. Cost of temporary utilities will be borne by Contractor and shall be included in the Contract Cost. Costs include activation of the service, meter costs, extending service to designated areas, and service costs.

B. Power:

1. Determine type and amount available and make arrangements for obtaining temporary electric power service, metering equipment, and pay all costs for electric power used during contract period, except for portions of the Work designated in writing by Engineer as substantially complete.
2. Cost of electric power will be borne by Contractor.

C. Lighting: Provide temporary lighting to meet applicable safety requirements to allow erection, application, or installation of materials and equipment, and observation or inspection of the Work.

D. Heating, Cooling, and Ventilating:

1. Provide as required to maintain adequate environmental conditions to facilitate progress of the Work, to meet specified minimum conditions for installation of materials, and to protect materials, equipment, and finishes from damage because of temperature or humidity. Costs for temporary heat shall be borne by Contractor responsible for constructing structure or building as specified in Section 01 11 00, Summary of Work.
2. Provide adequate forced air ventilation of enclosed areas to cure installed materials, to dispense humidity, and to prevent hazardous accumulations of dust, fumes, vapors, or gases.
3. Pay costs of installation, maintenance, operation, removal, and fuel consumed.

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4. Provide portable unit heaters, complete with controls, oil- or gas-fired, and suitably vented to outside as required for protection of health and property.
5. If permanent natural gas piping is used for temporary heating units, do not modify or reroute gas piping without approval of utility company. Provide separate gas metering as required by utility.

E. Water:

1. Hydrant Water:
   a. Is available from nearby hydrants. Secure written permission for connection and use from water department and meet requirements for use. Notify fire department before obtaining water from fire hydrants.
   b. Contractor must obtain temporary construction meter from the City of Tulsa. Contractor is responsible for payment of water usage.
   c. Use only special hydrant-operating wrenches to open hydrants. Make certain hydrant valve is open full, since cracking valve causes damage to hydrant. Repair damaged hydrants and notify appropriate agency as quickly as possible. Hydrants shall be completely accessible to fire department at all times.
   d. Include costs to connect and transport water to construction areas in Contract Price.
2. Owner will provide a place of temporary connection for construction water at Site. Provide temporary facilities and piping required to bring water to point of use and remove when no longer needed. Install an acceptable metering device and pay for water used at Owner’s current rate.
3. Provide and bear costs of necessary water required for testing equipment, tanks or basins, and piping prior to Substantial Completion, unless otherwise specifically stated in Specifications for equipment, systems, or facilities to be tested.
4. Provide a means to prevent water used for testing from flowing back into source pipeline.

F. Sanitary and Personnel Facilities:

1. Provide and maintain facilities for Contractor’s employees, Subcontractors, and other onsite employers’ employees. Service, clean, and maintain facilities and enclosures.
2. Use of Owner’s existing sanitary facilities by construction personnel will not be allowed.

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G. Fire Protection: Furnish and maintain on Site adequate firefighting equipment capable of extinguishing incipient fires. Comply with applicable parts of NFPA 241.

3.03 PROTECTION OF WORK AND PROPERTY

A. General:

1. Perform Work within right-of-way and easements in a systematic manner that minimizes inconvenience to property owners and the public.
2. Maintain in continuous service existing oil and gas pipelines, underground power, telephone or communication cable, water mains, irrigation lines, sewers, poles and overhead power, and other utilities encountered along line of the Work, unless other arrangements satisfactory to owners of said utilities have been made.
3. Where completion of the Work requires temporary or permanent removal or relocation of existing utility, coordinate activities with owner of said utility and perform work to their satisfaction.
4. Protect, shore, brace, support, and maintain underground pipes, conduits, drains, and other underground utility construction uncovered or otherwise affected by construction operations.
5. Keep fire hydrants and water control valves free from obstruction and available for use at all times.
6. In areas where Contractor’s operations are adjacent to or near a utility, such as gas, telephone, television, electric power, water, sewer, or irrigation system, and such operations may cause damage or inconvenience, suspend operations until arrangements necessary for protection have been made by Contractor.
7. Notify property owners and utility offices that may be affected by construction operation at least 2 days in advance. Before exposing a utility, obtain utility owner’s permission. Should service of utility be interrupted due to Contractor’s operation, notify proper authority immediately. Cooperate with said authority in restoring service as promptly as possible and bear costs incurred.
8. Do not impair operation of existing sewer system. Prevent construction material, pavement, concrete, earth, volatile and corrosive wastes, and other debris from entering sewers, pump stations, or other sewer structures.
9. Maintain original Site drainage wherever possible.

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B. Barricades and Lights:

1. Provide as required by the Vehicle Code and in sufficient quantity to safeguard public and the Work.
2. Provide as necessary to prevent unauthorized entry to construction areas and affected roads, streets, and alleyways, inside and outside of fenced area, and as required to ensure public safety and the safety of Contractor's employees, other employer's employees, and others who may be affected by the Work.
3. Provide to protect existing facilities and adjacent properties from potential damage.
4. Locate to enable access by facility operators and property owners.
5. Protect streets, roads, highways, and other public thoroughfares that are closed to traffic by effective barricades with acceptable warning signs.
6. Locate barricades at the nearest intersecting public thoroughfare on each side of blocked section.
7. Illuminate barricades and obstructions with warning lights from sunset to sunrise.

C. Trees and Plantings:

1. Protect from damage and preserve trees, shrubs, and other plants outside limits of the Work and within limits of the Work, which are designated on Drawings to remain undisturbed.
   a. Where practical, tunnel beneath trees when on or near line of trench.
   b. Employ hand excavation as necessary to prevent tree injury.
   c. Do not stockpile materials or permit traffic within drip lines of trees.
   d. Provide and maintain temporary barricades around trees.
   e. Water vegetation as necessary to maintain health.
   f. Cover temporarily exposed roots with wet burlap, and keep burlap moist until soil is replaced around roots.
   g. No trees, except those specifically shown on Drawings to be removed, shall be removed without written approval of Engineer.
   h. Dispose of removed trees in a legal manner off the Site.
2. Balling and burlapping of trees indicated for replacement shall conform to recommended specifications set forth in the American Standards for Nursery Stock, published by American Nursery and Landscape Association. Balls shall be firm and intact and made-balls will not be accepted. Handle ball and burlap trees by ball and not by top.
3. In event of damage to bark, trunks, limbs, or roots of plants that are not designated for removal, treat damage by corrective pruning, bark tracing, application of a heavy coating of tree paint, and other accepted horticultural and tree surgery practices.
4. Replace each plant that dies as a result of construction activities.

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D. Existing Structures:

1. Where Contractor contemplates removal of small structures such as mailboxes, signposts, and culverts that interfere with Contractor's operations, obtain approval of property owner and Engineer.
2. Move mailboxes to temporary locations accessible to postal service.
3. Replace items removed in their original location and a condition equal to or better than original.

E. Finished Construction: Protect finished floors and concrete floors exposed as well as those covered with composition tile or other applied surfacing.

F. Waterways: Keep ditches, culverts, and natural drainages continuously free of construction materials and debris.

G. Dewatering: Construct, maintain, and operate cofferdams, channels, flume drains, sumps, pumps, or other temporary diversion and protection works. Furnish materials required, install, maintain, and operate necessary pumping and other equipment for the environmentally safe removal and disposal of water from the various parts of the Work. Maintain foundations and parts of the Work free from water.

3.04 TEMPORARY CONTROLS

A. Air Pollution Control:

1. Minimize air pollution from construction operations.
2. Burning of waste materials, rubbish, or other debris will not be permitted on or adjacent to Site.
3. Conduct operations of dumping rock and of carrying rock away in trucks to cause a minimum of dust. Give unpaved streets, roads, detours, or haul roads used in construction area a dust-preventive treatment or periodically water to prevent dust. Strictly adhere to applicable environmental regulations for dust prevention.
4. Provide and maintain temporary dust-tight partitions, bulkheads, or other protective devices during construction to permit normal operation of existing facilities. Construct partitions of plywood, insulating board, plastic sheets, or similar material. Construct partitions in such a manner that dust and dirt from demolition and cutting will not enter other parts of existing building or facilities. Remove temporary partitions as soon as need no longer exists.

B. Noise Control: Provide acoustical barriers so noise emanating from tools or equipment will not exceed legal noise levels.

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C. Water Pollution Control:

1. Divert sanitary sewage and nonstorm waste flow interfering with construction and requiring diversion to sanitary sewers. Do not cause or permit action to occur which would cause an overflow to existing waterway.
2. Prior to commencing excavation and construction, obtain Owner's agreement with detailed plans showing procedures intended to handle and dispose of sewage, groundwater, and dewatering pump discharges.
3. Comply with procedures outlined in U.S. Environmental Protection Agency manuals entitled, "Guidelines for Erosion and Sedimentation Control Planning" and "Implementation, Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity," and "Erosion and Sediment Control-Surface Mining in Eastern United States."
4. Do not dispose of volatile wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains. Disposal of wastes into streams or waterways is prohibited. Provide acceptable containers for collection and disposal of waste materials, debris, and rubbish.

D. Erosion, Sediment, and Flood Control: Provide, maintain, and operate temporary facilities to control erosion and sediment releases, and to protect the Work and existing facilities from flooding during construction period.

3.05 STORAGE YARDS AND BUILDINGS

A. Coordinate requirements with Section 01 61 00, Common Product Requirements.

B. Temporary Storage Yards: Construct temporary storage yards for storage of products that are not subject to damage by weather conditions.

C. Temporary Storage Buildings:

1. Provide environmental control systems that meet recommendations of manufacturers of equipment and materials stored.
2. Arrange or partition to provide security of contents and ready access for inspection and inventory.

D. Store combustible materials (paints, solvents, fuels) in a well-ventilated and remote building meeting safety standards.

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3.06 PARKING AREAS

A. Control vehicular parking to preclude interference with public traffic or parking, access by emergency vehicles, Owner's operations, or construction operations.

B. Provide parking facilities for personnel working on Project. No employee or equipment parking will be permitted on Owner's existing paved areas, except as specifically designated for Contractor's use.

3.07 VEHICULAR TRAFFIC

A. Comply with Laws and Regulations regarding closing or restricting use of public streets or highways. No public or private road shall be closed, except by written permission of proper authority. Ensure the least possible obstruction to traffic and normal commercial pursuits.

B. Conduct the Work to interfere as little as possible with public travel, whether vehicular or pedestrian.

C. Whenever it is necessary to cross, close, or obstruct roads, driveways, and walks, whether public or private, provide and maintain suitable and safe bridges, detours, or other temporary expedients for accommodation of public and private travel.

3.08 CLEANING DURING CONSTRUCTION

A. In accordance with General Conditions, as may be specified in other Specification sections, and as required herein.

B. Wet down exterior surfaces prior to sweeping to prevent blowing of dust and debris. At least weekly, sweep floors (basins, tunnels, platforms, walkways, roof surfaces), and pick up and dispose of debris.

C. Provide approved containers for collection and disposal of waste materials, debris, and rubbish. At least weekly, dispose of such waste materials, debris, and rubbish offsite.

D. At least weekly, brush sweep entry drive, roadways, and other streets and walkways affected by the Work and where adjacent to the Work.

END OF SECTION

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SECTION 01 61 00
COMMON PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 DEFINITIONS

A. Products:

1. New items for incorporation in the Work, whether purchased by Contractor or Owner for the Project, or taken from previously purchased stock, and may also include existing materials or components required for reuse.
2. Includes the terms material, equipment, machinery, components, subsystem, system, hardware, software, and terms of similar intent and is not intended to change meaning of such other terms used in Contract Documents, as those terms are self-explanatory and have well recognized meanings in construction industry.
3. Items identified by manufacturer's product name, including make or model designation, indicated in manufacturer's published product literature, that is current as of the date of the Contract Documents.

1.02 DESIGN REQUIREMENTS

A. Where Contractor design is specified, design of installation, systems, equipment, and components, including supports and anchorage, shall be in accordance with provisions of latest edition of 2006 International Building Code (IBC) by International Code Council.

1. Project specific structural and other design loads are provided on the General Structural Note Sheets on Drawings.

1.03 ENVIRONMENTAL REQUIREMENTS

A. Altitude: Provide materials and equipment suitable for installation and operation under rated conditions at 600 feet above sea level.

B. Provide equipment and devices installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 10 degrees F to 130 degrees F.

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1.04 PREPARATION FOR SHIPMENT

A. When practical, factory assemble products. Mark or tag separate parts and assemblies to facilitate field assembly. Cover machined and unpainted parts that may be damaged by the elements with strippable protective coating.

B. Package products to facilitate handling and protect from damage during shipping, handling, and storage. Mark or tag outside of each package or crate to indicate its purchase order number, bill of lading number, contents by name, name of Project and Contractor, equipment number, and approximate weight. Include complete packing list and bill of materials with each shipment.

C. Extra Materials, Special Tools, Test Equipment, and Expendables:

1. Furnish as required by individual Specifications.
2. Schedule:
    a. Ensure that shipment and delivery occurs concurrent with shipment of associated equipment.
    b. Transfer to Owner shall occur immediately subsequent to Contractor's acceptance of equipment from Supplier.
3. Packaging and Shipment:
    a. Package and ship extra materials and special tools to avoid damage during long term storage in original cartons insofar as possible, or in appropriately sized, hinged-cover, wood, plastic, or metal box.
    b. Prominently displayed on each package, the following:
        1) Manufacturer's part nomenclature and number, consistent with Operation and Maintenance Manual identification system.
        2) Applicable equipment description.
        3) Quantity of parts in package.
        4) Equipment manufacturer.
4. Deliver materials to Site.
5. Notify Owner upon arrival for transfer materials.
6. Replace extra materials and special tools found to be damaged or otherwise inoperable at time of transfer to Owner.

D. Request a minimum 7-day advance notice of shipment from manufacturer.

E. Factory Test Results: Reviewed and accepted by Engineer before product shipment as required in individual Specification sections.

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1.05 DELIVERY AND INSPECTION

A. Deliver products in accordance with accepted current Progress Schedule and coordinate to avoid conflict with the Work and conditions at Site. Deliver anchor bolts and templates sufficiently early to permit setting prior to placement of structural concrete.

B. Deliver products in undamaged condition, in manufacturer's original container or packaging, with identifying labels intact and legible. Include on label, date of manufacture and shelf life, where applicable.

C. Unload products in accordance with manufacturer's instructions for unloading or as specified. Record receipt of products at Site. Promptly inspect for completeness and evidence of damage during shipment.

D. Remove damaged products from Site and expedite delivery of identical new undamaged products, and remedy incomplete or lost products to provide that specified, so as not to delay progress of the Work.

1.06 HANDLING, STORAGE, AND PROTECTION

A. Handle and store products in accordance with manufacturer's written instructions and in a manner to prevent damage. Store in approved storage yards or sheds provided in accordance with Section 01 50 00, Temporary Facilities and Controls. Provide manufacturer's recommended maintenance during storage, installation, and until products are accepted for use by Owner.

B. Manufacturer's instructions for material requiring special handling, storage, or protection shall be provided prior to delivery of material.

C. Arrange storage in a manner to provide easy access for inspection. Make periodic inspections of stored products to assure that products are maintained under specified conditions, and free from damage or deterioration. Keep running account of products in storage to facilitate inspection and to estimate progress payments for products delivered, but not installed in the Work.

D. Store electrical, instrumentation, and control products, and equipment with bearings in weather-tight structures maintained above 60 degrees F. Protect electrical, instrumentation, and control products, and insulate against moisture, water, and dust damage. Connect and operate continuously space heaters furnished in electrical equipment.

E. Store fabricated products above ground on blocking or skids, and prevent soiling or staining. Store loose granular materials in well-drained area on solid surface to prevent mixing with foreign matter. Cover products that are subject

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to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.

F. Store finished products that are ready for installation in dry and well-ventilated areas. Do not subject to extreme changes in temperature or humidity.

G. After installation, provide coverings to protect products from damage due to traffic and construction operations. Remove coverings when no longer needed.

H. Hazardous Materials: Prevent contamination of personnel, storage area, and Site. Meet requirements of product specification, codes, and manufacturer's instructions.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide manufacturer's standard materials suitable for service conditions, unless otherwise specified in the individual Specifications.

B. Where product specifications include a named manufacturer, with or without model number, and also include performance requirements, named manufacturer's products must meet the performance specifications.

C. Like items of products furnished and installed in the Work shall be end products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation and maintenance, spare parts and replacement, manufacturer's services, and implement same or similar process instrumentation and control functions in same or similar manner.

D. Do not use materials and equipment removed from existing premises, except as specifically permitted by Contract Documents.

E. Provide interchangeable components of the same manufacturer, for similar components, unless otherwise specified.

F. Equipment, Components, Systems, and Subsystems: Design and manufacture with due regard for health and safety of operation, maintenance, and accessibility, durability of parts, and shall comply with applicable OSHA, state, and local health and safety regulations.

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G. Regulatory Requirement: Coating materials shall meet federal, state, and local requirements limiting the emission of volatile organic compounds and for worker exposure.

H. Safety Guards: Provide for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Cover rotating part on all sides. Design for easy installation and removal. Use 16-gauge or heavier; galvanized steel, aluminum coated steel, or galvanized or aluminum coated 1/2-inch mesh expanded steel. Provide galvanized steel accessories and supports, including bolts. For outdoors application, prevent entrance of rain and dripping water.

I. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

J. Equipment Finish:

1. Provide manufacturer’s standard finish and color, except where specific color is indicated.
2. If manufacturer has no standard color, provide equipment with gray finish as approved by Owner.

K. Special Tools and Accessories: Furnish to Owner, upon acceptance of equipment, all accessories required to place each item of equipment in full operation. These accessory items include, but are not limited to, adequate oil and grease (as required for first lubrication of equipment after field testing), light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other spare parts as required for maintenance.

L. Equipment Tags:

1. All equipment tagged on Drawings and on the Equipment Table, except for submerged equipment shall be provided with number plates bearing the equipment tag number identified on Drawings and Equipment Table. Number plates shall be 12-gauge stainless steel with engraved or imprinted equipment tag number. Lettering on tags shall be 3/4 inch high. Number plates shall be rectangular with smooth edges, and shall

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be fastened to the equipment with stainless steel panhead screws, rivets, or drive screws.

2. When a number plate cannot be installed due to the physical size, space, or mounting surface geometry of the equipment, the Contractor shall provide a 12-gauge stainless steel tag with engraved or imprinted equipment tag number. Lettering on tags shall be 1/4 inch high. Tags shall be rectangular with smooth edges, and shall be fastened to the equipment with stainless steel mechanical fasteners or with a stainless steel chain.
3. Lubricant: Provide initial lubricant recommended by equipment manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by Owner.

2.02 FABRICATION AND MANUFACTURE

A. General:

1. Manufacture parts to U.S.A. standard sizes and gauges.
2. Two or more items of the same type shall be identical, by the same manufacturer, and interchangeable.
3. Design structural members for anticipated shock and vibratory loads.
4. Use 1/4-inch minimum thickness for steel that will be submerged, wholly or partially, during normal operation.
5. Modify standard products as necessary to meet performance Specifications.

B. Lubrication System:

1. Require no more than weekly attention during continuous operation.
2. Convenient and accessible; oil drains with bronze or stainless steel valves and fill-plugs easily accessible from the normal operating area or platform. Locate drains to allow convenient collection of oil during oil changes without removing equipment from its installed position.
3. Provide constant-level oilers or oil level indicators for oil lubrication systems.
4. For grease type bearings, which are not easily accessible, provide and install stainless steel tubing; protect and extend tubing to convenient location with suitable grease fitting.

2.03 SOURCE QUALITY CONTROL

A. Where Specifications call for factory testing to be witnessed by Engineer, notify Engineer not less than 14 days prior to scheduled test date, unless otherwise specified.

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B. Calibration Instruments: Bear the seal of a reputable laboratory certifying instrument has been calibrated within the previous 12 months to a standard endorsed by the National Institute of Standards and Technology (NIST).

C. Factory Tests: Perform in accordance with accepted test procedures and document successful completion.

PART 3 EXECUTION

3.01 INSPECTION

A. Inspect materials and equipment for signs of pitting, rust decay, or other deleterious effects of storage. Do not install material or equipment showing such effects. Remove damaged material or equipment from the Site and expedite delivery of identical new material or equipment. Delays to the Work resulting from material or equipment damage that necessitates procurement of new products will be considered delays within Contractor's control.

3.02 INSTALLATION

A. Equipment Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.

B. No shimming between machined surfaces is allowed.

C. Install the Work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Repaint painted surfaces that are damaged prior to equipment acceptance.

E. Do not cut or notch any structural member or building surface without specific approval of Engineer.

F. Handle, install, connect, clean, condition, and adjust products in accordance with manufacturer's instructions, and as may be specified. Retain a copy of manufacturers' instruction at Site, available for review at all times.

G. For material and equipment specifically indicated or specified to be reused in the Work:

1. Use special care in removal, handling, storage, and reinstallation to assure proper function in the completed Work.
2. Arrange for transportation, storage, and handling of products that require offsite storage, restoration, or renovation. Include costs for such Work in the Contract Price.

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3.03 FIELD FINISHING

A. In accordance with Section 09 90 00, Painting and Coating, and individual Specification sections.

3.04 ADJUSTMENT AND CLEANING

A. Perform required adjustments, tests, operation checks, and other startup activities.

3.05 LUBRICANTS

A. Fill lubricant reservoirs and replace consumption during testing, startup, and operation prior to acceptance of equipment by Owner.

END OF SECTION

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SECTION 01 77 00
CLOSEOUT PROCEDURES

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Submit prior to application for final payment.
   a. Record Documents: As required in General Conditions.
   b. Special bonds, Special Guarantees, and Service Agreements.
   c. Consent of Surety to Final Payment: As required in General Conditions.
   d. Releases or Waivers of Liens and Claims: As required in General Conditions.
   e. Releases from Agreements.
   f. Final Application for Payment: Submit in accordance with procedures and requirements stated in Section 01 29 00, Payment Procedures.
   g. Extra Materials: As required by individual Specification sections.

1.02 RECORD DOCUMENTS

A. Quality Assurance:

1. Furnish qualified and experienced person, whose duty and responsibility shall be to maintain record documents.
2. Accuracy of Records:
   a. Coordinate changes within record documents, making legible and accurate entries on each sheet of Drawings and other documents where such entry is required to show change.
   b. Purpose of Project record documents is to document factual information regarding aspects of the Work, both concealed and visible, to enable future modification of the Work to proceed without lengthy and expensive Site measurement, investigation, and examination.
3. Make entries within 24 hours after receipt of information that a change in the Work has occurred.
4. Prior to submitting each request for progress payment, request Engineer's review and approval of current status of record documents. Failure to properly maintain, update, and submit record documents may result in a deferral by Engineer to recommend whole or any part of Contractor's Application for Payment, either partial or final.

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1.03 RELEASES FROM AGREEMENTS

A. Furnish Owner written releases from property owners or public agencies where side agreements or special easements have been made, or where Contractor's operations have not been kept within the Owner's construction right-of-way.

B. In the event Contractor is unable to secure written releases:

1. Inform Owner of the reasons.
2. Owner or its representatives will examine the Site, and Owner will direct Contractor to complete the Work that may be necessary to satisfy terms of the side agreement or special easement.
3. Should Contractor refuse to perform this Work, Owner reserves right to have it done by separate contract and deduct cost of same from Contract Price, or require Contractor to furnish a satisfactory bond in a sum to cover legal Claims for damages.
4. When Owner is satisfied that the Work has been completed in agreement with Contract Documents and terms of side agreement or special easement, right is reserved to waive requirement for written release if: (i) Contractor's failure to obtain such statement is due to grantor's refusal to sign, and this refusal is not based upon any legitimate Claims that Contractor has failed to fulfill terms of side agreement or special easement, or (ii) Contractor is unable to contact or has had undue hardship in contacting grantor.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 MAINTENANCE OF RECORD DOCUMENTS

A. General:

1. Promptly following commencement of Contract Times, secure from Engineer at no cost to Contractor, one complete set of Contract Documents. Drawings will be full size.
2. Label or stamp each record document with title, "RECORD DOCUMENTS," in neat large printed letters.
3. Record information concurrently with construction progress and within 24 hours after receipt of information that change has occurred. Do not cover or conceal Work until required information is recorded.

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B. Preservation:

1. Maintain documents in a clean, dry, legible condition and in good order. Do not use record documents for construction purposes.
2. Make documents and Samples available at all times for observation by Engineer.

C. Making Entries on Drawings:

1. Using an erasable colored pencil (not ink or indelible pencil), clearly describe change by graphic line and note as required.
   a. Color Coding:
      1) Green when showing information deleted from Drawings.
      2) Red when showing information added to Drawings.
      3) Blue and circled in blue to show notes.
2. Date entries.
3. Call attention to entry by “cloud” drawn around area or areas affected.
4. Legibly mark to record actual changes made during construction, including, but not limited to:
   a. Depths of various elements of foundation in relation to finished first floor data if not shown or where depth differs from that shown.
   b. Horizontal and vertical locations of existing and new Underground Facilities and appurtenances, and other underground structures, equipment, or Work. Reference to at least two measurements to permanent surface improvements.
   c. Location of internal utilities and appurtenances concealed in the construction referenced to visible and accessible features of the structure.
   d. Locate existing facilities, piping, equipment, and items critical to the interface between existing physical conditions or construction and new construction.
   e. Changes made by Addenda and Field Orders, Work Change Directive, Change Order, and Engineer’s written interpretation and clarification using consistent symbols for each and showing appropriate document tracking number.
5. Dimensions on Schematic Layouts: Show on record drawings, by dimension, the centerline of each run of items such as are described in previous subparagraph above.
   a. Clearly identify the item by accurate note such as “cast iron drain,” “galv. water,” and the like.
   b. Show, by symbol or note, vertical location of item (“under slab,” “in ceiling plenum,” “exposed,” and the like).

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c. Make identification so descriptive that it may be related reliably to Specifications.

3.02 FINAL CLEANING

A. At completion of the Work or of a part thereof and immediately prior to Contractor's request for certificate of Substantial Completion; or if no certificate is issued, immediately prior to Contractor's notice of completion, clean entire Site or parts thereof, as applicable.

1. Leave the Work and adjacent areas affected in a cleaned condition satisfactory to Owner and Engineer.
2. Remove grease, dirt, dust, paint or plaster splatter, stains, labels, fingerprints, and other foreign materials from exposed surfaces.
3. Repair, patch, and touch up marred surfaces to specified finish and match adjacent surfaces.
4. Clean all windows.
5. Broom clean exterior paved driveways and parking areas.
6. Hose clean sidewalks, loading areas, and others contiguous with principal structures.
7. Rake clean all other surfaces.
8. Remove snow and ice from access to buildings.
9. Replace air-handling filters and clean ducts, blowers, and coils of ventilation units operated during construction.
10. Leave water courses, gutters, and ditches open and clean.

B. Use only cleaning materials recommended by manufacturer of surfaces to be cleaned.

END OF SECTION

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SECTION 01 78 23
OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Detailed information for the preparation, submission, and Engineer's review of Operations and Maintenance (O&M) Data, as required by individual Specification sections.

1.02 DEFINITIONS

A. Preliminary Data: Initial and subsequent submissions for Engineer's review.

B. Final Data: Engineer-accepted data, submitted as specified herein.

C. Maintenance Operation: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of equipment. Examples of typical maintenance operations are lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.

1.03 SEQUENCING AND SCHEDULING

A. Equipment and System Data:

1. Preliminary Data:
   a. Do not submit until Shop Drawing for equipment or system has been reviewed and approved by Engineer.
   b. Submit prior to shipment date.
2. Final Data: Submit Compilation Formatted data not less than 30 days prior to installation of equipment or system.

B. Materials and Finishes Data:

1. Preliminary Data: Submit at least 15 days prior to request for final inspection.
2. Final Data: Submit within 10 days after final inspection.

1.04 DATA FORMAT

A. Prepare preliminary and final data in the form of an instructional manual and on electronic media.

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B. Instructional Manual Format:

1. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.
2. Size: 8-1/2 inches by 11 inches, minimum.
3. Cover: Identify manual with typed or printed title “OPERATION AND MAINTENANCE DATA” and list:
    a. Project title.
    b. Designate applicable system, equipment, material, or finish.
    c. Identity of separate structure as applicable.
    d. Identify volume number if more than one volume.
    e. Identity of general subject matter covered in manual.
    f. Identity of equipment number and Specification section.
4. Spine:
    a. Project title.
    b. Identify volume number if more than one volume.
5. Title Page:
    a. Contractor name, address, and telephone number.
    b. Subcontractor, Supplier, installer, or maintenance contractor’s name, address, and telephone number, as appropriate.
        1) Identify area of responsibility of each.
        2) Provide name and telephone number of local source of supply for parts and replacement.
6. Table of Contents:
    a. Neatly typewritten and arranged in systematic order with consecutive page numbers.
    b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
7. Paper: 20-pound minimum, white for typed pages.
8. Text: Manufacturer’s printed data, or neatly typewritten.
9. Three-hole punch data for binding and composition; arrange printing so that punched holes do not obliterate data.
10. Material shall be suitable for reproduction, with quality equal to original. Photocopying of material will be acceptable, except for material containing photographs.

A. Data Compilation Format:

1. Compile all Engineer-accepted preliminary O&M data into a hard-copy, hard-bound set.
2. Each set shall consist of the following:
    a. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.

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b. Cover: Identify each volume with typed or printed title "OPERATION AND MAINTENANCE DATA, VOLUME NO. ___ OF ___", and list:
   1) Project title.
   2) Contractor's name, address, and telephone number.
   3) If entire volume covers equipment or system provided by one Supplier include the following:
      a) Identity of general subject matter covered in manual.
      b) Identity of equipment number and Specification section.

c. Provide each volume with title page and typed table of contents with consecutive page numbers. Place contents of entire set, identified by volume number, in each binder.

d. Table of contents neatly typewritten, arranged in a systematic order:
   1) Include list of each product, indexed to content of each volume.
   2) Designate system or equipment for which it is intended.
   3) Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.

e. Section Dividers:
   1) Heavy, 80 pound cover weight, tabbed with numbered plastic index tabs.
   2) Fly-Leaf:
      a) For each separate product, or each piece of operating equipment, with typed description of product and major component parts of equipment.
      b) List with Each Product:
         (1) Name, address, and telephone number of Subcontractor, Supplier, installer, and maintenance contractor, as appropriate.
         (2) Identify area of responsibility of each.
         (3) Provide local source of supply for parts and replacement.
      c) Identity of separate structure as applicable.

f. Assemble and bind material, as much as possible, in same order as specified in the Contract Documents.

B. Electronic Media Format:

1. Portable Document Format (PDF):
   a. After all preliminary data has been found to be acceptable to Engineer, submit Operation and Maintenance data in PDF format on CD. PDF shall be indexed with each chapter or Tab indexed.

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b. Files to be exact duplicates of Engineer-accepted preliminary data. Arrange by specification number and name.
c. Files to be fully functional and viewable in most recent version of Adobe Acrobat.

1.05 SUBMITTALS

A. Informational:

1. Data Outline: Submit two copies of a detailed outline of proposed organization and contents of Final Data prior to preparation of Preliminary Data.
2. Preliminary Data:
   a. Submit three copies for Engineer's review.
   b. If data meets conditions of the Contract:
      1) One copy will be returned to Contractor.
      2) One copy will be forwarded to Resident Project Representative.
      3) One copy will be retained in Engineer's file.
   c. If data does not meet conditions of the Contract:
      1) All copies will be returned to Contractor with Engineer's comments (on separate document) for revision.
      2) Engineer's comments will be retained in Engineer's file.
      3) Resubmit two copies revised in accordance with Engineer's comments.
3. Final Data: Submit two copies in format specified herein.

1.06 DATA FOR EQUIPMENT AND SYSTEMS

A. Content For Each Unit (or Common Units) and System:

1. Product Data:
   a. Include only those sheets that are pertinent to specific product.
   b. Clearly annotate each sheet to:
      1) Identify specific product or part installed.
      2) Identify data applicable to installation.
      3) Delete references to inapplicable information.
   c. Function, normal operating characteristics, and limiting conditions.
   d. Performance curves, engineering data, nameplate data, and tests.
   e. Complete nomenclature and commercial number of replaceable parts.

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f. Original manufacturer's parts list, illustrations, detailed assembly drawings showing each part with part numbers and sequentially numbered parts list, and diagrams required for maintenance.
g. Spare parts ordering instructions.
h. Where applicable, identify installed spares and other provisions for future work (e.g., reserved panel space, unused components, wiring, terminals).

2. As-installed, color-coded piping diagrams.
3. Charts of valve tag numbers, with the location and function of each valve.
4. Drawings: Supplement product data with Drawings as necessary to clearly illustrate:
   a. Format:
      1) Provide reinforced, punched, binder tab; bind in with text.
      2) Reduced to 8-1/2 inches by 11 inches, or 11 inches by 17 inches folded to 8-1/2 inches by 11 inches.
      3) Where reduction is impractical, fold and place in 8-1/2-inch by 11-inch envelopes bound in text.
      4) Identify Specification section and product on Drawings and envelopes.
   b. Relations of component parts of equipment and systems.
   c. Control and flow diagrams.
   d. Coordinate drawings with Project record documents to assure correct illustration of completed installation.
5. Instructions and Procedures: Within text, as required to supplement product data.
   a. Format:
      1) Organize in consistent format under separate heading for each different procedure.
      2) Provide logical sequence of instructions for each procedure.
      3) Provide information sheet for Owner's personnel, including:
         a) Proper procedures in event of failure.
         b) Instances that might affect validity of guarantee or Bond.
   b. Installation Instructions: Including alignment, adjusting, calibrating, and checking.
   c. Operating Procedures:
      1) Startup, break-in, routine, and normal operating instructions.
      2) Test procedures and results of factory tests where required.
      3) Regulation, control, stopping, and emergency instructions.
      4) Description of operation sequence by control manufacturer.
      5) Shutdown instructions for both short and extended duration.
      6) Summer and winter operating instructions, as applicable.
      7) Safety precautions.

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8) Special operating instructions.

d. Maintenance and Overhaul Procedures:

1) Routine maintenance.
2) Guide to troubleshooting.
3) Disassembly, removal, repair, reinstallation, and re-assembly.

6. Guarantee, Bond, and Service Agreement: In accordance with Section 01 77 00, Closeout Procedures.
7. Lucity Database Asset Management Spreadsheet: Contractor shall complete the Lucity Database Asset Management spreadsheet, attached to the end of this section, for each piece of equipment valued at more than $1,000. Contractor shall complete all columns in the spreadsheet that are identified as the responsibility of the Contractor. An electronic version of the spreadsheet will be provided by Owner after contract is awarded.

B. Content for Each Electric or Electronic Item or System:

1. Description of Unit and Component Parts:
   a. Function, normal operating characteristics, and limiting conditions.
   b. Performance curves, engineering data, nameplate data, and tests.
   c. Complete nomenclature and commercial number of replaceable parts.
   d. Interconnection wiring diagrams, including control and lighting systems.
2. Circuit Directories of Panelboards:
   a. Electrical service.
   b. Control requirements and interfaces.
   c. Communication requirements and interfaces.
   d. List of electrical relay settings, and control and alarm contact settings.
   e. Electrical interconnection wiring diagram, including as applicable, single-line, three-line, schematic and internal wiring, and external interconnection wiring.
   f. As-installed control diagrams by control manufacturer.
3. Operating Procedures:
   a. Routine and normal operating instructions.
   b. Startup and shutdown sequences, normal and emergency.
   c. Safety precautions.
   d. Special operating instructions.

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4. Maintenance Procedures:
    a. Routine maintenance.
    b. Guide to troubleshooting.
    c. Adjustment and checking.
    d. List of relay settings, control and alarm contact settings.
5. Manufacturer's printed operating and maintenance instructions.
6. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.

C. Maintenance Summary:

1. Compile individual Maintenance Summary for each applicable equipment item, respective unit or system, and for components or sub-units.
2. Format:
    a. Use Maintenance Summary Form bound with this section or electronic facsimile of such.
    b. Each Maintenance Summary may take as many pages as required.
    c. Use only 8-1/2-inch by 11-inch size paper.
    d. Complete using typewriter or electronic printing.
3. Include detailed lubrication instructions and diagrams showing points to be greased or oiled; recommend type, grade, and temperature range of lubricants and frequency of lubrication.
4. Recommended Spare Parts:
    a. Data to be consistent with manufacturer's Bill of Materials/Parts List furnished in O&M manuals.
    b. "Unit" is the unit of measure for ordering the part.
    c. "Quantity" is the number of units recommended.
    d. "Unit Cost" is the current purchase price.

1.07 DATA FOR MATERIALS AND FINISHES

A. Content for Architectural Products, Applied Materials, and Finishes:

1. Manufacturer's data, giving full information on products:
    a. Catalog number, size, and composition.
    b. Color and texture designations.
    c. Information required for reordering special-manufactured products.
2. Instructions for Care and Maintenance:
    a. Manufacturer's recommendation for types of cleaning agents and methods.
    b. Cautions against cleaning agents and methods that are detrimental to product.

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c. Recommended schedule for cleaning and maintenance.

B. Content for Moisture Protection and Weather Exposed Products:

1. Manufacturer's data, giving full information on products:
   a. Applicable standards.
   b. Chemical composition.
   c. Details of installation.
2. Instructions for inspection, maintenance, and repair.

1.08 SUPPLEMENT

A. The supplement listed below, following "End of Section," is part of this Specification.

1. Maintenance Summary Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

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MAINTENANCE SUMMARY FORM

PROJECT:_____ CONTRACT NO.:_____

1. EQUIPMENT ITEM_____

2. MANUFACTURER _____

3. EQUIPMENT/TAG NUMBER(S) _____

4. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS)_____

5. NAMEPLATE DATA (hp, voltage, speed, etc.) _____

6. MANUFACTURER'S LOCAL REPRESENTATIVE _____

   a. Name_____ Telephone No. _____

   b. Address _____

7. MAINTENANCE REQUIREMENTS

Maintenance Operation Comments	**Frequency**	**Lubricant (If Applicable)**
List briefly each maintenance operation required and refer to specific information in manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.)	List required frequency of each maintenance operation.	Refer by symbol to lubricant required.

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8. LUBRICANT LIST

Reference Symbol	Shell	Exxon Mobile	Chevron Texaco	BP Amoco	Or Equal
List symbols used in No. 7 above.	List equivalent lubricants, as distributed by each manufacturer for the specific use recommended.				

9. RECOMMENDED SPARE PARTS FOR OWNER'S INVENTORY.

Part No.	Description	Unit	Quantity	Unit Cost
Note: Identify parts provided by this Contract with two asterisks.				

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SECTION 01 88 15
ANCHORAGE AND BRACING

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for anchorage and bracing of equipment, distribution systems, and other nonstructural components required in accordance with the ICC 2018 International Building Code (IBC), for seismic, wind, gravity, soil, and operational loads.

1.02 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.

B. Designated Seismic System: Architectural, electrical, and mechanical system or their components for which component importance factor is greater than 1.0.

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. General:

1. Anchorage and bracing systems shall be designed by a qualified professional engineer registered in the State of Oklahoma.
2. Design anchorage and bracing of architectural, mechanical, and electrical components and systems in accordance with this section, unless a design is specifically provided within Contract Documents or where exempted hereinafter.
3. Design attachments, braces, and anchors for equipment, components, and distribution systems to structure for gravity, seismic, wind, and operational loading.
4. Piping and ductwork, whether exempt or not exempt for this section, shall be anchored and braced so that lateral or vertical displacement does not result in damage or failure to essential architectural, mechanical, or electrical equipment.

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5. Architectural Components: Includes, but are not limited to, nonstructural walls and elements, partitions, cladding and veneer, access flooring, signs, cabinets, suspended ceilings, and glass in glazed curtain walls and partitions.
6. Provide supplementary framing where required to transfer anchorage and bracing loads to structure.
7. Adjust equipment pad sizes or provide additional anchorage confinement reinforcing to provide required anchorage capacities.
8. Design seismic anchorage and bracing for:
    a. Equipment and components that weigh more than 400 pounds and are mounted 4 feet or less above adjacent finished floor.
    b. Equipment weighing more than 40 pounds that is mounted more than 4 feet above adjacent finished floor.
    c. Mechanical and electrical components that are not provided with flexible connections between components and associated ductwork, piping, or conduit.
    d. Distribution systems that weigh more than 5 pounds per foot that are mounted more than 4 feet above adjacent finished floor.
9. For components exempted from design requirements of this section, provide bolted, welded, or otherwise positively fastened attachments to supporting structure.

B. Design Loads:

1. Gravity: Design anchorage and bracing for self-weight and superimposed loads on components and equipment.
2. Wind: Design anchorage and bracing for wind criteria provided on General Structural Notes on Drawings for exposed architectural components and exterior and wind-exposed mechanical and electrical equipment. Alternately, manufacturer certification may be provided for components such as roofing and flashing to verify attachments meet Project-specific design criteria.
3. Operational:
    a. For loading supplied by equipment manufacturer for IBC required load cases.
    b. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), water hammer, and other load-inducing conditions.
    c. Locate braces to minimize vibration to or movement of structure.
    d. For vibrating loads, use anchors meeting requirements of Section 05 50 00, Metal Fabrications, for anchors with designated capacities for vibratory loading per manufacturer’s ICC-ES report.

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4. Hydraulic: Design of anchorage for submerged gates and other mechanical equipment shall include hydrostatic and hydrodynamic loads determined in accordance with Section 15.7 of ASCE 7-10.
5. Seismic:
    a. In accordance with 2015 IBC, Section 1613, and Chapter 13 of ASCE 7.
    b. Design anchorage and bracing for design criteria listed on General Structural Notes on Drawings.

C. Seismic Design Requirements:

1. Analyze local region of body of nonstructural component for load transfer of anchorage attachment if component Ip equals 1.5.
2. Support drawings and calculations for electrical distribution components shall be provided if any of the following conditions apply:
    a. Ip is equal to 1.5 and conduit diameter is greater than 2.5-inch trade size.
    b. Ip is equal to 1.5 and the total weight of bus duct, cable tray, or conduit supported by trapeze assemblies exceeds 10 pounds per foot.
    c. Supports are cantilevered up from floor.
    d. Supports include bracing to limit deflection and are constructed as rigid welded frames.
    e. Attachments utilize spot welds, plug welds, or minimum size welds as defined by AISC.
3. Other seismic design and detailing requirements identified in ASCE 7 are required to be provided for new architectural, mechanical and electrical components, systems, or equipment.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. List of architectural, mechanical, and electrical equipment requiring Contractor-designed anchorage and bracing, unless specifically exempted.
    b. Manufacturers' engineered seismic hardware product data.
    c. Seismic attachment assemblies' drawings; include connection hardware, braces, and anchors or anchor bolts for nonexempt components, equipment, and systems. Shop drawings shall be sealed by a civil or structural engineer registered in the State of Oklahoma.

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d. Submittal will be rejected if proposed anchorage method would create an overstressed condition of supporting member. Revise anchorages and strengthening of structural support so there is no overstressed condition.

B. Informational Submittals:

1. Anchorage and Bracing Calculations: For attachments, braces, and anchorages, include IBC and Project-specific criteria as noted on General Structural Notes on Drawings, in addition to manufacturer's specific criteria used for design; sealed by a civil or structural engineer registered in the State of Oklahoma.
2. Manufacturer's hardware installation requirements.

C. Deferred Submittals:

1. Submitted anchorage drawings and calculations are identified as IBC deferred submittals and will be submitted to and accepted by AHJ prior to installation of component, equipment or distribution system.
2. Submit deferred action submittals such as shop drawings with supporting deferred informational submittals such as calculations no less than 4 weeks in advance of installation of component, equipment or distribution system to be anchored to structure.

1.05 SOURCE QUALITY CONTROL

A. Contractor and supplier responsibilities to accommodate Owner-furnished shop fabrication related special inspections and testing are provided in Project's Statement of Special Inspections on Drawings and Section 01 45 33, Special Inspection, Observation, and Testing.

B. All other specified, regulatory required, or repair verification inspection and testing that are not listed in Statement of Special Inspections, are to be provided by Contractor and shall meet requirements of Section 01 45 16.13, Contractor Quality Control.

C. Source Quality Control for shall be in accordance with Section 05 50 00, Metal Fabrications.

PART 2 PRODUCTS

2.01 GENERAL

A. Attachments and supports transferring seismic loads to structure shall be designed and constructed of materials and products suitable for application

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and be in accordance with design criteria shown on Drawings and nationally recognized standards.

B. Provide anchor bolts and concrete anchors for anchorage of equipment to concrete in accordance with Section 05 50 00, Metal Fabrications. Size of anchor bolts and anchors, required minimum embedment, and spacing shall be based on calculations submitted by Contractor.

C. Do not use powder-actuated fasteners or sleeve anchors for seismic attachments and anchorage where resistance to tension loads is required. Do not use expansion anchors, other than undercut anchors, for nonvibration isolated mechanical equipment rated over 10 hp.

PART 3 EXECUTION

3.01 GENERAL

A. Make attachments, bracing, and anchorage in such a manner that component lateral force is transferred to lateral force resisting system of structure through a complete load path.

B. Overall seismic anchorage system shall provide restraint in all directions, including vertical, for each component or system so anchored.

C. Components mounted on vibration isolation systems shall have snubbers in each horizontal direction and vertical restraints where required to resist overturning.

D. Anchor piping in such a manner as to ensure piping system has adequate flexibility and expansion capabilities at flexible connections and expansion joints.

1. Piping and ductwork suspended more than 12 inches below supporting structure shall be braced for seismic effects to avoid significant bending of hangers and their attachments.

E. Anchor tall and narrow equipment such as motor control centers and telemetry equipment at base and within 12 inches from top of equipment, unless approved otherwise by Engineer.

F. Do not attach architectural, mechanical, or electrical components to more than one element of a building structure at a single restraint location where such elements may respond differently during a seismic event. Do not make such attachments across building expansion and contraction joints.

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3.02 INSTALLATION

A. Do not install components or their anchorages or restraints prior to review and acceptance by Engineer and AHJ.

B. Notify Engineer upon completion of installation of seismic restraints in accordance with Section 01 45 33, Special Inspection, Observation, and Testing.

3.03 FIELD QUALITY CONTROL

A. In accordance with Section 05 50 00, Metal Fabrications.

B. Contractor responsibilities to accommodate Owner-furnished special inspections and testing are provided in Project's Statement of Special Inspections on Drawings and Section 01 45 33, Special Inspection, Observation, and Testing.

C. Any other specified, regulatory required, or repair verification inspection and testing that are not listed in Statement of Special Inspections, are to be provided by Contractor and shall meet requirements of Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

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SECTION 01 91 14
EQUIPMENT TESTING AND FACILITY STARTUP

PART 1 GENERAL

1.01 DEFINITIONS

A. Facility: Entire Project, or an agreed-upon portion, including all of its unit processes.

B. Functional Test: Test or tests in presence of Engineer and Owner to demonstrate that installed equipment meets manufacturer's installation, calibration, and adjustment requirements and other requirements as specified.

C. Performance Test: Test or tests performed after any required functional test in presence of Engineer and Owner to demonstrate and confirm individual equipment meets performance requirements specified in individual sections.

D. Unit Process: As used in this section, a unit process is a portion of the facility that performs a specific process function, such as flocculation and conveyance.

E. Facility Performance Demonstration:

1. A demonstration, conducted by Contractor, with assistance of Owner, to demonstrate and document the performance of the entire operating facility, both manually and automatically (if required), based on criteria developed in conjunction with Owner and as accepted by Engineer.
2. Such demonstration is for the purposes of (i) verifying to Owner entire facility performs as a whole, and (ii) documenting performance characteristics of completed facility for Owner's records. Neither the demonstration nor the evaluation is intended in any way to make performance of a unit process or entire facility the responsibility of Contractor, unless such performance is otherwise specified.

1.02 SUBMITTALS

A. Informational Submittals:

1. Facility Startup and Performance Demonstration Plan.
2. Functional and performance test results.
3. Completed Unit Process Startup Form for each unit process.
4. Completed Facility Performance Demonstration/Certification Form.

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5. Initial Condition Assessment: An initial condition assessment shall be provided for each asset installed before turning the asset over to the City or placing the Asset in service. The condition assessment shall use AM-AMF-965 and the condition assessment form.

1.03 FACILITY STARTUP AND PERFORMANCE DEMONSTRATION PLAN

A. Develop a written plan, in conjunction with Owner's operations personnel; to include the following:

1. Step-by-step instructions for startup of each unit process and the complete facility.
2. Unit Process Startup Form (sample attached), to minimally include the following:
   a. Description of the unit process, including equipment numbers/nomenclature of each item of equipment and all included devices.
   b. Detailed procedure for startup of the unit process, including valves to be opened/closed, order of equipment startup, etc.
   c. Startup requirements for each unit process, including water, power, chemicals, etc.
   d. Space for evaluation comments.
3. Facility Performance Demonstration/Certification Form (sample attached), to minimally include the following:
   a. Description of unit processes included in the facility startup.
   b. Sequence of unit process startup to achieve facility startup.
   c. Description of computerized operations, if any, included in the facility.
   d. Contractor certification facility is capable of performing its intended function(s), including fully automatic operation.
   e. Signature spaces for Contractor and Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Facility Startup Meetings: Schedule, in accordance with requirements of Section 01 31 19, Project Meetings, to discuss test schedule, test methods, materials, chemicals and liquids required, facilities operations interface, and Owner involvement.

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B. Contractor's Testing and Startup Representative:

1. Designate and furnish one or more personnel to coordinate and expedite testing and facility startup.
2. Representative(s) shall be present during startup meetings and shall be available at all times during testing and startup.

C. Provide temporary valves, gauges, piping, test equipment and other materials and equipment required for testing and startup.

D. Provide Subcontractor and equipment manufacturers' staff adequate to prevent delays. Schedule ongoing work so as not to interfere with or delay testing and startup.

E. Owner will:

1. Provide water, power, chemicals, and other items as required for startup, unless otherwise indicated.
2. Operate process units and facility with support of Contractor.
3. Provide labor and materials as required for laboratory analyses.

3.02 EQUIPMENT TESTING

A. Preparation:

1. Complete installation before testing.
2. Furnish qualified manufacturers' representatives, when required by individual Specification sections.
3. Obtain and submit from equipment manufacturer's representative Manufacturer's Certificate of Proper Installation Form, in accordance with Section 01 43 33, Manufacturers' Field Services, when required by individual Specification sections.
4. Equipment Test Report Form: Provide written test report for each item of equipment to be tested, to include the minimum information:
    a. Owner/Project Name.
    b. Equipment or item tested.
    c. Date and time of test.
    d. Type of test performed (Functional or Performance).
    e. Test method.
    f. Test conditions.
    g. Test results.
    h. Signature spaces for Contractor and Engineer as witness.
5. Cleaning and Checking: Prior to beginning functional testing:
    a. Calibrate testing equipment in accordance with manufacturer's instructions.

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b. Inspect and clean equipment, devices, connected piping, and structures to ensure they are free of foreign material.
c. Lubricate equipment in accordance with manufacturer's instructions.
d. Turn rotating equipment by hand when possible to confirm that equipment is not bound.
e. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
f. Check power supply to electric-powered equipment for correct voltage.
g. Adjust clearances and torque.
h. Test piping for leaks.

6. Ready-to-test determination will be by Engineer based at least on the following:
   a. Acceptable Operation and Maintenance Data.
   b. Notification by Contractor of equipment readiness for testing.
   c. Receipt of Manufacturer's Certificate of Proper Installation, if so specified.
   d. Adequate completion of work adjacent to, or interfacing with, equipment to be tested.
   e. Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment.
   f. Satisfactory fulfillment of other specified manufacturer's responsibilities.
   g. Equipment and electrical tagging complete.
   h. Delivery of all spare parts and special tools.

B. Functional Testing:

1. Conduct as specified in individual Specification sections.
2. Notify Owner and Engineer in writing at least 10 days prior to scheduled date of testing.
3. Prepare Equipment Test Report summarizing test method and results.
4. When, in Engineer's opinion, equipment meets functional requirements specified, such equipment will be accepted for purposes of advancing to performance testing phase, if so required by individual Specification sections. Such acceptance will be evidenced by Engineer/Owner's signature as witness on Equipment Test Report.

C. Performance Testing:

1. Conduct as specified in individual Specification sections.
2. Notify Engineer and Owner in writing at least 10 days prior to scheduled date of test.

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3. Performance testing shall not commence until equipment has been accepted by Engineer as having satisfied functional test requirements specified.
4. Type of fluid, gas, or solid for testing shall be as specified.
5. Unless otherwise indicated, furnish labor, materials, and supplies for conducting the test and taking samples and performance measurements.
6. Prepare Equipment Test Report summarizing test method and results.
7. When, in Engineer's opinion, equipment meets performance requirements specified, such equipment will be accepted as to conforming to Contract requirements. Such acceptance will be evidenced by Engineer's signature on Equipment Test Report.

3.03 STARTUP OF UNIT PROCESSES

A. Prior to unit process startup, equipment within unit process shall be accepted by Engineer as having met functional and performance testing requirements specified.

B. Startup sequencing of unit processes shall be as chosen by Contractor to meet schedule requirements.

C. Make adjustments, repairs, and corrections necessary to complete unit process startup.

D. Startup shall be considered complete when, in opinion of Engineer, unit process has operated in manner intended for 5 continuous days without significant interruption. This period is in addition to functional or performance test periods specified elsewhere.

E. Significant Interruption: May include any of the following events:

1. Failure of Contractor to provide and maintain qualified onsite startup personnel as scheduled.
2. Failure to meet specified functional operation for more than 2 consecutive hours.
3. Failure of any critical equipment or unit process that is not satisfactorily corrected within 4 hours after failure.
4. Failure of any noncritical equipment or unit process that is not satisfactorily corrected within 8 hours after failure.
5. As determined by Engineer.

F. A significant interruption will require startup then in progress to be stopped. After corrections are made, startup test period to start from beginning again.

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3.04 FACILITY PERFORMANCE DEMONSTRATION

A. When, in the opinion of Engineer, startup of all unit processes has been achieved, sequence each unit process to the point that facility is operational.

B. Demonstrate proper operation of required interfaces within and between individual unit processes.

C. After facility is operating, complete performance testing of equipment and systems not previously tested.

D. Document, as defined in Facility Startup and Performance Demonstration Plan, the performance of the facility including its computer system, until all unit processes are operable and under control of computer system.

E. Certify, on the Facility Performance Demonstration/Certification Form, that facility is capable of performing its intended function(s), including fully automatic and computerized operation.

3.05 SUPPLEMENTS

A. Supplements listed below, following “End of Section,” are a part of this Specification:

1. Unit Process Startup Form.
2. Facility Performance Demonstration/Certification Form.

END OF SECTION

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UNIT PROCESS STARTUP FORM

OWNER:_____ PROJECT:_____

Unit Process Description: (Include description and equipment number of all equipment and devices):

_____

_____

_____

_____

Startup Procedure (Describe procedure for sequential startup and evaluation, including valves to be opened/close order of equipment startup, etc.):

_____

_____

_____

_____

_____

Startup Requirements (Water, power, chemicals, etc.):_____

_____

_____

Evaluation Comments:_____

_____

_____

_____

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FACILITY PERFORMANCE DEMONSTRATION/CERTIFICATION FORM

OWNER:_____ PROJECT:_____

Unit Processes Description (List unit processes involved in facility startup):

_____

_____

_____

_____

Unit Processes Startup Sequence (Describe sequence for startup, including computerized operations, if any):

_____

_____

_____

_____

_____

Contractor Certification that Facility is capable of performing its intended function(s), including fully automatic operation:

Contractor: _____ Date: _____, 20____

Engineer: _____ Date: _____, 20____
(Authorized Signature)

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SECTION 02 41 00
DEMOLITION

PART 1 GENERAL

1.01 REFERENCES

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

1. American National Standards Institute (ANSI): A10.6, Safety Requirements for Demolition Operations.
2. Environmental Protection Agency (EPA), U.S. Code of Federal Regulations (CFR), Title 40:
   a. Part 61—National Emission Standards for Hazardous Air Pollutants.
   b. Part 273—Standards for Universal Waste Management.
3. Occupational Safety and Health Administration (OSHA), U.S. Code of Federal Regulations (CFR) Title 29 Part 1926—Occupational Safety and Health Regulations for Construction.

1.02 DEFINITIONS

A. Demolition: Dismantling, razing, destroying, or wrecking of any fixed building or structure or any part thereof. Demolition also includes removal of pipes, manholes tanks, conduit, and other underground facilities, whether as a separate activity or in conjunction with construction of new facilities.

B. Modify: Provide all necessary material and labor to modify an existing item to the condition indicated or specified.

C. Relocate: Remove, protect, clean and reinstall equipment, including electrical, instrumentation, and all ancillary components required to make the equipment fully functional, to the new location identified on the Drawings.

D. Renovation: Altering a facility or one or more facility components in any way.

E. Salvage/Salvageable: Remove and deliver, to the specified location(s), the equipment, building materials, or other items so identified to be saved from destruction, damage, or waste, such property to remain that of Owner. Unless otherwise specified, title to items identified for demolition shall revert to Contractor.

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1.03 SUBMITTALS

A. Informational Submittals:

1. Submit proposed Demolition/Renovation Plan, in accordance with requirements specified herein, for approval before such Work is started.
2. Submit copies of any notifications, authorizations and permits required to perform the Work.

1.04 REGULATORY AND SAFETY REQUIREMENTS

A. When applicable, demolition Work shall be accomplished in strict accordance with 29 CFR 1926-Subpart T.

B. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the General Conditions, Contractor's safety requirements shall conform to ANSI A10.6.

C. Furnish timely notification of this demolition project to applicable federal, state, regional, and local authorities in accordance with 40 CFR 61-Subpart M.

1.05 DEMOLITION/RENOVATION PLAN

A. Demolition/Renovation Plan shall provide for safe conduct of the Work and shall include:

1. Detailed description of methods and equipment to be used for each operation;
2. The Contractor's planned sequence of operations, including coordination with other work in progress;
3. Procedures for removal and disposition of materials specified to be salvaged.

B. Include statements affirming Contractor inspection of the existing roof deck, floors, walls, and framing members, and their suitability to perform as a safe working platform or, if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the Work.

1.06 SEQUENCING AND SCHEDULING

A. The Work of this Specification shall not commence until Contractor's Demolition/Renovation Plan has been approved by Engineer.

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B. Include the Work of this Specification in the progress schedule, as specified in Section 01 32 00, Construction Progress Documentation.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXISTING FACILITIES TO BE DEMOLISHED OR RENOVATED

A. Facilities: Buildings and adjacent designated areas scheduled for complete demolition are as shown.

B. Portions of buildings and other areas scheduled for selective demolition, partial demolition, and renovation Work are as shown. Structures:

1. Existing above-grade structures indicated shall be removed as shown.
2. Interior walls, other than retaining walls and partitions, shall be removed to top of concrete slab.
3. Partition walls shall be removed as shown.
4. Sidewalks, curbs, gutters and street light bases shall be removed as indicated.

C. Utilities and Related Equipment:

1. Notify Owner or appropriate utilities to turn off affected services at least 48 hours before starting demolition activities.
2. Remove existing utilities as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by Engineer.
3. When utility lines are encountered that are not indicated on the Drawings, notify Engineer prior to further work in that area.
4. Remove meters and related equipment and deliver to a location as determined by the Owner.
5. Excavate and remove utility lines serving buildings to be demolished to a distance of 10 feet beyond the outside perimeter of the demolition.
6. Provide a permanent leak-proof closure for water and gas lines.
7. Plug sewer lines with concrete to a minimum plug length of 2 feet to prevent groundwater infiltration.

D. Concrete:

1. Core drill corners of new opening to avoid overcutting adjacent reinforcing in existing concrete to remain. Saw concrete along straight lines to a depth of not less than 2 inches. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite

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face. Break out the remainder of the concrete provided that the broken area is concealed in the finished Work, and the remaining concrete is sound.

2. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete. Repair exposed rebar ends and embeds as shown on Drawings.
3. Where new concrete adjoins existing concrete, thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 3/16 inch. Rebar and small embeds at existing concrete may be required to be left to engage new concrete. Saturate surface with water for 24 hours prior to placing new concrete. The new Work shall tie into the existing construction as shown on Drawings.
4. At submerged locations not to receive new concrete, paint exposed rebar or metal embed ends with System No. 18a at potable water surfaces per Section 09 90 00, Painting and Coating.

E. Patching:

1. Where removals leave holes and damaged surfaces exposed in the finished Work, patch and repair to match adjacent finished surfaces as to texture and finish.
2. Where new Work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new Work.
3. Patching shall be as specified and indicated, and shall include: Fill holes and depressions caused by previous physical damage or left as a result of removals in existing concrete walls with an approved patching material, applied in accordance with the manufacturer's printed instructions.

F. Electrical:

1. Cut off concealed or embedded conduit, boxes, or other materials a minimum of 3/4 inch below final finished surface.
2. When removing designated equipment, conduit and wiring may require rework to maintain service to other equipment.
3. Rework existing circuits, or provide temporary circuits as necessary during renovation to maintain service to existing lighting and equipment not scheduled to be renovated. Existing equipment and circuiting shown are based upon limited field surveys. Verify existing conditions, make all necessary adjustments, and record the Work on Record Drawings. This shall include, but is not limited to, swapping and other adjustments to branch circuits and relocation of branch circuit breakers within panelboards as required to accomplish the finished work.

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4. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated.
5. Raceways and cabling not scheduled for reuse.
6. Inaccessibly Concealed: Cut off and abandon in place.
7. Raceways and Cabling Scheduled for Future Use: Cap/seal and tag.
8. Relocating Equipment: Extend existing wiring or run new wiring from the source.
9. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank cover plate installed.
10. Where the concealed raceway is uncovered remove raceway (or extended to new location if appropriate).
11. Provide new typewritten panelboard circuit directory cards.

G. Universal Waste Lamps and Thermostats: Manage, contain, package, and label in strict accordance with 40 CFR 273.

3.02 PROTECTION

A. Dust and Debris Control: Prevent the spread of dust and debris to other portions of the facility and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.

B. Existing Work:

1. Survey the site and examine the Drawings and Specifications to determine the extent of the Work before beginning any demolition or renovation.
2. Take necessary precautions to avoid damage to existing items scheduled to remain in place, to be reused, or to remain the property of Owner; any Contractor-damaged items shall be repaired or replaced as directed by Engineer.
3. Provide temporary weather protection during interval between removal of existing exterior surfaces and installation of new to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
4. Ensure that structural elements are not overloaded as a result of or during performance of the Work. Responsibility for additional structural elements or increasing the strength of existing structural elements as may be required as a result of any Work performed under this Contract shall be that of the Contractor. Repairs, reinforcement, or structural replacement must have Engineer approval.
5. Do not overload pavements to remain.

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C. Facilities:

1. Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities.
2. Floors, roofs, walls, columns, pilasters, and other structural elements that are designed and constructed to stand without lateral support or shoring, and are determined by Contractor to be in stable condition, shall remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Engineer.
3. Protect all facility elements not scheduled for demolition.
4. Provide interior shoring, bracing, or support to prevent movement, settlement, or collapse of structure or element to be demolished and adjacent facilities.

D. Protection of Personnel:

1. During demolition, continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site.
2. Provide temporary barricades and other forms of protection to protect Owner’s personnel and the general public from injury due to demolition Work.
3. Provide protective measures as required to provide free and safe passage of Owner’s personnel and the general public to occupied portions of the structure.

3.03 BACKFILL

A. Do not use demolition debris as backfill material.

B. Fill excavations, open basements and other hazardous openings to existing ground level or foundation level of new construction in accordance with Section 31 23 23, Fill and Backfill.

3.04 TITLE TO MATERIALS

A. With the exception of the following listed salvaged equipment, all items designated to be removed shall become the property of Contractor:

1. Instruments – pH probes, turbidimeters, SC 200 Controllers.
2. Control boxes, junction boxes and electrical disconnects.
3. PLC Cabinet.

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B. Title to equipment and materials resulting from demolition and not noted to be salvaged is vested in the Contractor upon approval by Engineer of Contractor's Demolition/Renovation Plan, and the resulting authorization by Engineer to begin demolition.

3.05 DISPOSITION OF MATERIAL

A. Do not remove equipment and materials without approval of Contractor's Demolition/Renovation Plan by Engineer.

B. Remove equipment that is specified to be salvaged and deliver to a storage site as directed by the Owner on the Site.

C. Remove salvaged items in a manner to prevent damage, and pack or crate to protect the items from damage while in storage or during shipment. Properly identify containers as to contents.

D. Repair or replace, at the discretion of Engineer, items specified to be salvaged that are damaged during removal or storage.

E. Owner will not be responsible for the condition or loss of, or damage to, property scheduled to become Contractor's property after Engineer's authorization to begin demolition. Materials and equipment shall not be viewed by prospective purchasers or sold on the site.

3.06 UNSALVAGEABLE MATERIAL

A. Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be disposed of in the following manner and location.

1. Off-site.

B. Combustible material shall be disposed of off the Site.

C. Universal Waste Lamps and Thermostats: Dispose of in strict accordance with 40 CFR 273.

3.07 CLEANUP

A. Debris and rubbish shall be removed from excavations. Debris and rubbish shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

END OF SECTION

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SECTION 03 01 32
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

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

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

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n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
o. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
p. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
q. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
r. D4259, Standard Practice for Abrading Concrete.
s. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

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

1.02 DEFINITIONS

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

B. Defective Area: As defined in Section 03 30 10, Structural Concrete.

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

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

E. New Concrete: As defined in Section 03 30 10, Structural Concrete.

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

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

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1.03 SUBMITTALS

A. Action Submittals:

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

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Mesh manufacturer's installation instructions and allowable load criteria.
3. Written description of equipment proposed for concrete removal and surface preparation.
4. Certificates:
   a. Shotcrete Nozzleman: Current ACI Certification for each proposed nozzleman.
   b. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, that proposed repair mortar systems:
      1) Meet or exceed specified performance criteria when tested in accordance with Article Field Quality Control.
      2) Are prepackaged, shrinkage compensated, specially designed for use on vertical and overhead surfaces that are exposed to weather and/or potable water.
   c. Mortar Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
   d. Confirmation material is certified to meet requirements of NSF 61 where exposure is potentially potable water.
5. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Repair mortar system manufacturer's representative.
   c. Independent Testing Laboratory.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator:
   a. Trained and experienced applicator recognized or certified by repair mortar system manufacturer.
   b. For Repair System B, in lieu of recognition or certification, demonstrate application of repair mortar manufacturer's system and obtain Certification of Proper Installation, in accordance with Article Manufacturer's Services.
2. Repair Mortar System Manufacturer's Representative: As specified in Section 01 43 33, Manufacturers' Field Services.

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

C. Demonstration Mockup for Shotcrete Mortar and/or Low-Pressure Spray Mortar Repair System depending on which system is proposed for use:

1. For each type of repair mortar system to be used, prepare one demonstration mockup in each vertical and overhead orientation of at least 5 feet by 5 feet with average thickness, and containing reinforcement, representative of area being repaired on Project. Alternatively, a repair area in each vertical and overhead orientation that is representative of area to be repaired in terms of size, thickness, and reinforcement, may be used for demonstration in lieu of mockups; subject to acceptance by Engineer.
2. Repair Mortar System Manufacturer's Demonstration:
   a. Schedule time for manufacturer's demonstration of repair system proposed for Project.
   b. Prepare mortar to specified consistency for testing and placement.
   c. Cure portions of each type of surface to be repaired using proposed curing procedure and materials, including overhead and vertical applications.
   d. Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.
   e. Demonstrate the following:
      1) Mixing and application equipment capabilities and procedures, including flow of material from nozzle or sprayer.
      2) Nozzle operator and person in charge of low-pressure sprayer, capabilities and ability to follow prescribed

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application procedures and properly operate equipment and apply surface repair materials.

f. Compression Strength Test: Make compression test samples from wet mortar during demonstration placement and deliver to independent testing laboratory for testing at 7 days and 28 days.

D. Demonstration Mockup for Hand-Applied Repair Mortar:

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

E. Pre-repair Conference:

1. Required Meeting Attendees:
   a. Contractor.
   b. Repair Subcontractor.
   c. Technical representative for repair material manufacturer.
   d. Engineer.
2. Schedule and conduct prior to conducting mockups and incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include, but not limited to:
   a. Review of field conditions. Conduct field observations of Work to be performed.

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b. Based on above observations, repair material manufacturer's technical representative shall confirm material selection and make Project-specific repair method recommendations.
c. Technical representative for repair material manufacturer shall review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

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

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

PART 2 PRODUCTS

2.01 SYSTEM A—SHOTCRETE MORTAR

A. Mortar Materials:

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

B. Mixed Mortar Properties:

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

C. Cured Mortar Properties:

1. Compressive strength for 2-inch cubes in accordance with ASTM C109/C109M, or 3-inch cubes in accordance with manufacturer's modification to ASTM C109/C109M:
   a. 7 Days: 6,000 psi minimum.
   b. 28 Days: 7,000 psi minimum.

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2. Flexural Strength (Modulus of Rupture), ASTM C78/C78M or ASTM C348 (Modified) at 28 Days: 1,100 psi minimum.
3. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 400 psi minimum.
4. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum.
5. Mortar shall not produce a vapor barrier.
6. Certified to meet requirements of NSF 61 for contact with potable water.

D. Manufacturers and Products: BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco® S 211SP Shotcrete.

2.02 SYSTEM B—LOW-PRESSURE SPRAY MORTAR

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

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

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

C. Manufacturers and Products:

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

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2.03 SYSTEM C—POLYMER-MODIFIED REPAIR MORTAR

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

B. Cured Mortar Properties:

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

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

2.04 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 10, Structural Concrete.

2.05 REINFORCEMENT

A. Deformed Reinforcing Bars:

1. ASTM A615/A615M, Grade 60.
2. Welding of reinforcing shall not be permitted.

B. Mesh Reinforcement: Welded wire fabric flat sheets with spacing of wires and wire size in accordance with ASTM A185/A185M, wire 75 ksi minimum tensile strength per ASTM A82/A82M, and repair mortar system manufacturer’s recommendations.

C. Tie Wire: 16-gauge, galvanized.

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D. Mesh Anchors:

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

2.06 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

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

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

B. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; Emaco P124.
2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
3. Euclid Chemical Co., Cleveland, OH: Dural Prep AC.

2.07 EVAPORATION RETARDANT

A. As specified in Section 03 30 10, Structural Concrete.

2.08 CURING COMPOUND

A. As specified in Section 03 30 10, Structural Concrete.

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PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system. Refer to Section 03 30 10, Structural Concrete.

B. Existing Concrete Work: Repair concrete as identified in Contract Documents.

3.02 PREPARATION

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

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

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

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

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

E. Remove unsound concrete to satisfaction of Engineer.

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

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

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

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

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

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

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

3.03 REINFORCEMENT INSTALLATION

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

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

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

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

E. Coat exposed new and existing reinforcing bars and reinforcement mesh with cementitious reinforcement coating at same time as substrate concrete is coated, as specified below, per repair mortar and cementitious reinforcement coating manufacturers' printed instructions.

3.04 PROTECTION

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

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

3.05 SYSTEM A—SHOTCRETE MORTAR APPLICATION

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

B. Do not reuse rebound materials.

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

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

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

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

G. Reinforcing Steel Encasement:

1. Modify procedure of shooting shotcrete mortar to better direct material around reinforcement bars.

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

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

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

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

K. Cure as specified in Article Curing.

3.06 SYSTEM B—LOW-PRESSURE SPRAY MORTAR APPLICATION

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

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

C. Bonding Agent:

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

D. Work mortar firmly and quickly into repair area.

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

F. Cure as specified in Article Curing.

3.07 SYSTEM C—POLYMER-MODIFIED REPAIR MORTAR APPLICATION

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

B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions.

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Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.

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

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

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

3.08 CURING

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

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

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

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

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

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

G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.09 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

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

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B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed wet mortar materials from nozzle, or mixer, during construction for compliance with Specifications for testing at 7 days, and 28 days. Alternatively, take core samples in accordance with ASTM C42/C42M from applied mortar material for testing at 7 days and 28 days.
3. Provide a minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Direct Tension Bond Test:

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

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

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

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

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

3.10 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

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

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

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

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

3.11 MANUFACTURER'S SERVICES

A. Provide repair mortar system manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for review acceptability of surface preparation, mixing and installation assistance, training of repair mortar system applicators, inspection, and Certification of Proper Installation.

3.12 CLEANING

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

END OF SECTION

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SECTION 03 01 33
REPAIR OF HORIZONTAL CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): T277, Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
2. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   j. C469, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
   k. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   l. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   m. C779/C779M, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.

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n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
o. C928/C928M, Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs.
p. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
q. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
r. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
s. D638, Standard Test Method for Tensile Properties of Plastics.
t. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
u. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
v. D4259, Standard Practice for Abrading Concrete.
w. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

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

1.02 DEFINITIONS

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

B. Defective Area: As defined in Section 03 30 10, Structural Concrete.

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

D. New Concrete: As defined in Section 03 30 10, Structural Concrete.

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1.03 SUBMITTALS

A. Action Submittals:

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

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Certificates:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, that material meets requirements of ASTM C928/C928M.
   b. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, that proposed repair mortar systems meet or exceed specified performance criteria when tested in accordance with Article Field Quality Control.
   c. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, that repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on horizontal surfaces that are exposed to weather, potable water, or receive traffic.
   d. Mortar Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
   e. Confirmation mortar materials meet requirements of NSF 61 where potentially exposed to potable water.
   f. Confirmation epoxy resin bonding agents conform to ASTM C882/C882M.
4. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Independent Testing Laboratory.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: Trained and experienced applicator endorsed by repair mortar system manufacturer.
2. Repair Mortar System Manufacturer's Representative: As specified in Section 01 43 33, Manufacturers' Field Services.

B. Prerepair Conference:

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

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

PART 2 PRODUCTS

2.01 SYSTEM NO. 2—HIGH EARLY STRENGTH REPAIR MORTAR

A. One-component, fast-setting, high early strength repair mortar.

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B. Compressive Strength, ASTM C109/C109M:

1. 2 Hours: 1,500 psi minimum.
2. 1 Day: 4,500 psi minimum.
3. 7 Days: 8,000 psi minimum.
4. 28 Days: 9,000 psi minimum.

C. Flexural Strength, ASTM C348:

1. 1 Day: 850 psi minimum.
2. 7 Days: 1,000 psi minimum.
3. 28 Days: 1,100 psi minimum.

D. Modulus of Elasticity, ASTM C469:

1. 1 Day: 3.8 by 10^6 psi minimum.
2. 28 Days: 4.5 by 10^6 psi minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M:

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 2,900 psi minimum.
3. 28 Days: 3,100 psi minimum.

F. Splitting Tensile Strength, ASTM C496/C496M:

1. 1 Day: 850 psi minimum.
2. 7 Days: 1,200 psi minimum.
3. 28 Days: 1,300 psi minimum.

G. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 98 percent RDM.

H. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 or AASHTO T277, 28 Days: 960 coulombs maximum.

I. Certified to meet requirements of NSF 61 for contact with potable water where proposed application will potentially be exposed to potable water.

J. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco T415.
2. Euclid Chemical Co., Cleveland, OH; VersaSpeed.

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2.02 SYSTEM NO. 3—SHRINKAGE COMPENSATED REPAIR MORTAR

A. One-component cement-based, flowable, shrinkage compensated repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 6,000 psi minimum.
3. 28 Days: 8,000 psi minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 770 psi minimum.

D. Modulus of Elasticity, ASTM C469 at 28 Days: 5.9 by 10^6 psi minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M Modified:

1. 7 Days: 2,150 psi minimum.
2. 28 Days: 3,000 psi minimum.

F. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 97 percent RDM.

G. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 at 28 Days: 650 coulombs maximum.

H. Sulfate Resistance, ASTM C1012/C1012M after 6 Months: 0.01 percent length change maximum.

I. Certified to meet requirements of NSF 61 for contact with potable water where proposed application will potentially be exposed to potable water.

J. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; Emaco S66 CI.
2. Euclid Chemical Co., Cleveland, OH; Eucocrete Supreme.

2.03 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 10, Structural Concrete.

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2.04 REINFORCEMENT

A. Deformed Reinforcing Bars:

1. ASTM A615/A615M, Grade 60.
2. Welding of reinforcing shall not be permitted.

B. Mesh Reinforcement: Welded wire fabric flat sheets with spacing of wires and wire size in accordance with ASTM A185/A185M, wire 75 ksi minimum tensile strength per ASTM A82/A82M, and repair mortar system manufacturer's recommendations.

C. Tie Wire: 16-gauge, galvanized.

D. Mesh Anchors:

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

2.05 EPOXY BONDING AGENT

A. Two-component, moisture insensitive, 100 percent solids epoxy resin.

B. Tensile Strength, ASTM D638, at 14 Days: 4,400 psi minimum.

C. Elongation at Break, ASTM D638: 1.49 percent minimum.

D. Compressive Strength, ASTM D695, at 28 Days for Application Temperature of 73 Degrees F to 77 Degrees F: 8,000 psi minimum.

E. Bond Strength, ASTM C882/C882M, at 14 Days: 1,800 psi minimum.

F. Pot Life, at 73 Degrees F to 77 Degrees F: 75 minutes minimum.

G. Manufacturers and Products: BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco® ADH 326 when ambient temperature is 73 degrees F or higher.

2.06 EVAPORATION RETARDANT

A. As specified in Section 03 30 10, Structural Concrete.

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2.07 CURING COMPOUND

A. As specified in Section 03 30 10, Structural Concrete.

PART 3 EXECUTION

3.01 GENERAL

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

B. Existing Concrete Work: Repair concrete as identified in Contract Documents.

3.02 PREPARATION

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

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

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

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

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

E. Remove unsound concrete to satisfaction of Engineer.

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

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

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

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

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

J. Substrate Concrete Surface in Areas to Receive Repair Mortar System Nos. 2 and 3: Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar, as required by and in accordance with repair mortar manufacturer’s printed instructions.

K. Spalled Joints:

1. Saw cut edge 1 inch deep and 6 inches back from old joint.
2. Remove unsound concrete and concrete between saw cut and joint.
3. Place wood or fiber spacer to thickness of joint at joint line.

L. Overlays:

1. Square cut edges to a minimum of 1/4 inch deep.
2. Do not feather edge area.
3. Perform special preparation recommended by mortar manufacturer.

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

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3.03 REINFORCMENT INSTALLATION

A. Provide reinforcement when existing reinforcement is not exposed, and when mortar application is more than 4 inches deep, unless otherwise shown on Drawings.

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

C. Fasten reinforcement to chairs or mesh anchors with tie wire to prevent from moving during placement of repair mortar.

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

3.04 PROTECTION

A. Protect adjacent surfaces, and equipment from spillage of repair mortar and dust, as applicable for repair mortar system used.

3.05 APPLICATION

A. General:

1. Repair Mortar System No. 2: Patches, joints, or overlays 1/2 inch to 3 inches thick. Return to service in 3 hours to 7 days.
2. Repair Mortar System No. 3: Patches, joints, or overlays 1 inch thick or greater. Return to service in 7 days or more.

B. Repair Mortar System Nos. 2 and 3:

1. Remove standing and free water from prepared area.
2. Apply bond scrub coat of mortar to prepared surface in accordance with manufacturer's instructions. Do not apply more scrub coat of mortar than can be covered with repair mortar before scrub coat begins drying.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.
7. Repair Mortar System No. 5 screed or use self-leveling mixture to obtain a uniform and plane surface.

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C. Joint Repair:

1. Remove joint spacer when repair mortar is hard enough that a pointed trowel will penetrate surface less than 1/2 inch.
2. When repair mortar is cured and ready for use, fill joint in accordance with repair mortar system manufacturer's instructions.

3.06 CURING

A. Repair Mortar System Nos. 2, and 3: Apply curing compound in accordance with Section 03 30 10, Structural Concrete.

3.07 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

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

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed materials from mixer during construction for compliance with Specifications.
3. Provide minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Direct Tension Bond Test:

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

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

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

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

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

3.08 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

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

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

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

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

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3.09 MANUFACTURERS' SERVICES

A. Provide mortar manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for advice on product selection, review acceptability of surface preparation, mixing and installation assistance, inspection, and Certification of Proper Installation.

3.10 CLEANING

A. Remove excess repair mortar materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of repair areas, finishing, and curing, and dispose offsite at approved disposal site.

END OF SECTION

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SECTION 03 30 10
STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 REFERENCES

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

1. American Concrete Institute (ACI):
   a. 117, Specifications for Tolerances for Concrete Construction and Materials.
   b. 301-10, Specifications for Structural Concrete.
   c. 305.1, Specification for Hot Weather Concreting.
   d. 306.1, Specification for Cold Weather Concreting.
   e. 350.1, Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures.
   f. SP-66, Detailing Manual.
2. ASTM International (ASTM):
   a. A497/A497M, Standard Specification for Steel Welded Reinforcement, Deformed, for Concrete.
   b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   d. C33/C33M, Standard Specification for Concrete Aggregates.
   e. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   f. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   g. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
   h. C150/C150M, Standard Specification for Portland Cement.
   i. C227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).
   j. C231/C231M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   k. C260/C260M, Standard Specification for Air-Entraining Admixtures for Concrete.
   l. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   m. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.

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n. C595/C595M, Standard Specification for Blended Hydraulic Cements.
o. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
p. C920, Specification for Elastomeric Joint Sealants.
q. C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
r. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
s. C1017/C1017M, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
t. C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
u. C1218/C1218M, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
v. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
w. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
x. C 1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
y. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
z. C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
aa. D227, Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing.
bb. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
cc. D1056, Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
dd. D1751, Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
ee. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

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ff. D2240, Standard Test Method for Rubber Property – Durometer Hardness.
gg. E329, Standard Specification for Agencies Engaged in Construction Inspection, Special Inspection, or Testing Materials Used in Construction.

3. Concrete Reinforcing Steel Institute (CRSI):
   a. Manual of Standard Practice.
   b. Recommended Practice for Placing Reinforcing Bars.
4. Corps of Engineers (COE): CRD-C-572, Corps of Engineers Specifications for Polyvinylchloride Waterstop.
5. National Ready Mixed Concrete Association (NRMCA).
6. NSF International (NSF): 61, Drinking Water System Components - Health Effects.

1.02 DEFINITIONS

A. Cold Weather: When ambient temperature is below 40 degrees F or is approaching 40 degrees F and falling.

B. Contractor's Licensed Design Engineer: Individual representing Contractor who is licensed to practice engineering as defined by statutory requirements of professional licensing laws in state or jurisdiction in which Project is to be constructed.

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

D. Exposed Concrete: Concrete surface that can be seen inside or outside of structure regardless of whether concrete is above water, dry at all times, or can be seen when structure is drained.

E. Hot Weather: As defined in ACI 305.1.

F. Hydraulic Structure: Liquid containment structure.

G. New Concrete: Concrete less than 60 days old.

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H. Top Bars: Horizontal bars placed such that 12 inches of fresh concrete is cast below in single placement.

1.03 DESIGN REQUIREMENTS

A. Design formwork in accordance with requirements of ACI 301 to provide specified concrete finishes.

B. Joints in forms shall not leak concrete mortar.

C. Limit panel deflection to 1/240th of each component span to achieve tolerances specified.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Formwork and Formwork Accessories: Unless otherwise specified, conform to requirements of ACI 301.
   b. Shop drawings showing construction layouts, water-stop locations, and concrete pouring plans.
   c. Reinforcing steel prepared in accordance with CRSI Manual of Standard Practice and ACI SP-66 Detailing Manual:
      1) Bending lists.
      2) Placing drawings.
2. Mix Design:
   a. Contain proportions of materials and admixtures to be used on Project, signed by mix designer.
   b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
   c. Manufacturer’s Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers’ Field Services, for the following:
      1) Portland cement.
      2) Aggregates, including specified class designation for coarse aggregate.
      3) Admixtures.
      4) Concrete producer has verified compatibility of constituent materials in design mix.
   d. Test Reports:
      1) Cement: Chemical analysis report.
      2) NSF/ANSI 61 Concrete Certification (required only for the Clarifier No. 3 and Mixer Box concrete).
      3) NSF/ANSI Certification for all materials in direct contact with potable water. (Clarifier 3 and Mixer Box).

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4) Supplementary Cementitious Materials: Chemical analysis report and report of other specified test analyses.
5) Water-Soluble Chloride-Ion Content in Hardened Concrete: Unless otherwise permitted, in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

e. Aggregates:
1) Coarse Aggregate Gradation: List gradings and percent passing through each sieve.
2) Fine Aggregate Gradation: List gradings and percent passing through each sieve.
3) Percent of fine aggregate weight to total aggregate weight.
4) Deleterious substances in fine aggregate per ASTM C33/C33M, Table 1.
5) Deleterious substances in coarse aggregate per ASTM C33/C33M, Table 3.
6) Test Reports:
a) Alkali Aggregate Reactivity: Aggregate shall be classified as nonpotentially reactive in accordance with Article Concrete Mix Design. Include documentation of test results per applicable standards.

f. Admixtures: Manufacturer's product data sheets for each admixture used in proposed mix designs.

3. Product Data: Specified ancillary materials.
4. Detailed plan for curing and protection of concrete placed and cured in cold weather. Details shall include, but not be limited to, the following:
a. Procedures for protecting subgrade from frost and accumulation of ice or snow on reinforcement, other metallic embeds, and forms prior to placement.
b. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
c. Methods for temperature protection during placement.
d. Types of covering, insulation, housing, or heating to be provided.
e. Curing methods to be used during and following protection period.
f. Use of strength accelerating admixtures.
g. Methods for verification of in-place strength.
h. Documentation of embeds that must be at a temperature above freezing prior to placement of concrete.
i. Procedures for measuring and recording concrete temperatures.
j. Procedures for preventing drying during dry, windy conditions.
5. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F. Plan shall include, but not be limited to, the following:
a. Procedures for measuring, and recording temperatures of reinforcement and other embedded items prior to concrete placement.

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b. Use of retarding admixture.
c. Methods for controlling temperature of reinforcement and other embedded items and concrete materials before and during placement.
d. Types of shading and wind protection to be provided.
e. Curing methods, including use of evaporation retardant.
f. Procedures for measuring and recording concrete temperatures.
g. Procedures for preventing drying during dry, windy conditions.

6. Concrete repair techniques.

B. Informational Submittals:

1. Manufacturer's application instructions for bonding agent and bond breaker.
2. Manufacturer's Certificate of Compliance to specified standards:
   a. Bonding agent.
   b. Bond breaker.
   c. Repair materials.
3. Statement of Qualification:
   a. Batch Plant: Certification as specified herein.
   b. Installer.
   c. Mix designer.
   d. Testing agency.
4. Manufacturer's written instructions for product shipment, storage, handling, installation/application, and repair for: Waterstop.

1.05 QUALITY ASSURANCE

A. Concrete construction shall conform to requirements of ACI 117 and ACI 301, except as modified herein.

B. Qualifications:

1. Batch Plant: NRMCA Program for Certification of Ready-Mixed Concrete Production Facilities or approved equivalent program.
2. Mix Designer: Person responsible for developing concrete mixture proportions certified as NRMCA Concrete Technologist Level 2 or DOT certified mix designer in jurisdiction of the Work. Requirement may be waived if individual is Contractor's Licensed Professional Engineer.
3. Flatwork Finisher: Unless otherwise permitted, at least one person on finishing crew shall be certified as an ACI Flatwork Finisher, or equivalent.
4. Testing Agency: Unless otherwise permitted, an independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.
   a. Where field testing is required of Contractor, personnel conducting field tests shall be qualified as ACI Concrete Field Testing

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Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

b. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

C. Preinstallation Conference:

1. Required Meeting Attendees:
   a. Contractor, including pumping, placing and finishing, and curing subcontractors.
   b. Ready-mix producer.
   c. Admixture representative.
   d. Testing and sampling personnel.
   e. Engineer or Engineer's designee.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include:
   a. Admixture types, dosage, performance, and redosing at Site.
   b. Mix designs, test of mixes, and Submittals.
   c. Placement methods, techniques, equipment, consolidation, and form pressures.
   d. Slump and placement time to maintain slump.
   e. Finish, curing, and water retention.
   f. Protection procedures for weather conditions.
   g. NSF/ANSI 61 Concrete Certification (required only for the Clarifier 3, and Mixer Boxes concrete).
   h. Other specified requirements requiring coordination.
4. Conference minutes as specified in Section 01 31 19, Project Meetings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Unload, store, and handle bars in accordance with CRSI publication "Placing Reinforcing Bars."

PART 2 PRODUCTS

2.01 GENERAL

A. Products shall be in accordance with requirements of ACI 301, unless otherwise noted.

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2.02 FORMWORK

A. Form Materials:

1. For exposed areas, use hard plastic finished plywood, overlaid waterproof particle board, or steel in “new and undamaged” condition, of sufficient strength and surface smoothness to produce specified finish.
2. For unexposed areas, use new shiplap or plywood.
3. Earth cuts may be used for forming footings.

B. Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

C. Form Ties:

1. Material: Steel.
2. Spreader Inserts:
   a. Conical or spherical type.
   b. Design to maintain positive contact with forming material.
   c. Furnish units that will leave no metal closer than 1.5 inches to concrete surface when forms, inserts, and tie ends are removed.
3. Wire ties not permitted.

D. Form Snap-Ties with Water Stop:

1. For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
   a. Neoprene waterstop 3/16-inch-thick and 15/16-inch diameter whose center hole is one half diameter of tie, or molded plastic water stop of comparable size.
   b. Orient waterstop perpendicular to tie and symmetrical about center of tie.
   c. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.

2.03 CONCRETE

A. Materials: Unless otherwise specified, in accordance with ACI 301.

1. Cementitious Materials:
   a. Cement:
      1) Portland Cement: Unless otherwise specified, conform to requirements of ASTM C150/C150M.

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2) Blended Hydraulic Cement:
   a) Unless otherwise specified, conform to requirements of ASTM C595/C595M.
   b) Portland cement used in blended hydraulic cement; conform to requirements of ASTM C150/C150M.
3) Furnish from one source.

2. Aggregates: Unless otherwise permitted, furnish from one source for each aggregate type used in a mix design.
   a. Normal-Weight Aggregates:
      1) In accordance with ASTM C33/C33M, except as modified herein.
         a) Class Designation: 4S unless otherwise specified.
         b) Free of materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.
         c) Alkali Silica Reactivity: See Article Concrete Mix Design.
      2) Fine Aggregates:
         a) Clean, sharp, natural sand.
         b) ASTM C33/C33M.
         c) Limit deleterious substances in accordance with ASTM C33/C33M, Table 1 and as follows:
            (1) Limit material finer than 75-µm (No. 200) sieve to 3 percent mass of total sample.
            (2) Limit coal and lignite to 0.5 percent.
      3) Coarse Aggregate:
         a) Natural gravels, combination of gravels and crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles (long dimension more than five times the short dimension).
         b) Limit deleterious substances in accordance with ASTM C33/C33M, Table 3 for specified class designation.
3. Admixtures: Unless otherwise permitted, furnish from one manufacturer.
   a. Characteristics:
      1) Compatible with other constituents in mix.
      2) Contain at most, only trace amount chlorides in solution.
      3) Furnish type of admixture as recommended by manufacturer for anticipated temperature ranges.
   b. Air-Entraining Admixture: ASTM C260/C260M.
   c. Water-Reducing Admixture: ASTM C494/C494M, Type A or Type D.
   d. Retarding Admixture: ASTM C494/C494M, Type B.

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e. Accelerating Admixture: ASTM C 494/C 494M, Type C.
f. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F or Type G.
g. Plasticizing Admixture: ASTM C1017/C1017M, Type I or Type II.
h. Do not use calcium chloride as an admixture.
i. Admixtures with no standard, ASTM or other, designation may be used where permitted.

4. Water and Ice: Mixing water for concrete and water used to make ice shall be potable water, unless alternative sources of water are permitted.
   a. Water from alternative sources shall comply with requirements of ASTM C1602/C1602M, and concentration of chemicals in combined mixing water shall be less than:
      1) Chloride Content: 1,000 ppm.
      2) Sulfate Content as SO_4: 3,000 ppm.
      3) Alkalis as (Na_2O + 0.658 K_2O): 600 ppm.
      4) Total Solids by Mass: Less than 50,000 ppm.

B. Concrete Mix Design:

1. General:
   a. Concrete shall meet the of NSF/ANSI 61 requirements for Clarifier No. 3 and mixer boxers.
   b. See Supplement at the end of this section for mix design requirements for each class of concrete used on Project.
   c. Prepare design mixtures for each type and strength of concrete, selecting and proportioning ingredients in accordance with requirements of ACI 301, unless otherwise specified.
   d. Selection of constituent materials and products in mix design are optional, unless specified otherwise.
   e. Unless otherwise permitted, use water-reducing admixture or water-reducing admixture and high-range, water-reducing admixture, or plasticizing admixture in pumped concrete, in concrete with a water-cementitious materials ratio below 0.50, and in concrete that is part of a liquid-containment structure.
   f. Unless otherwise permitted, use water-reducing admixture and high-range, water-reducing admixture, or plasticizing admixture in columns, piers, pilasters, and walls.
   g. Use water-reducing admixture or high-range, water-reducing admixture, or plasticizing admixture to achieve fresh properties that facilitate handling, placing, and consolidating of concrete, and specified hardened properties.
   h. Use water-reducing and retarding admixture when anticipated high temperatures, low humidity, or other adverse placement conditions can adversely affect fresh properties of concrete.

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i. Unless otherwise specified, desired fresh properties of concrete shall be determined by Contractor and coordinated with concrete producer. Fresh properties of concrete shall remain stable to satisfaction of Contractor, for duration of placement and consolidation, and shall remain in conformance with requirements of Contract Documents.

j. Contractor is encouraged to consider using environmentally sustainable concrete mix design technologies such as use of supplementary cementitious materials, aggregate packing, and self-consolidating concrete.

2. Potential Alkali-aggregate Reactivity of Concrete:
   a. Do not use aggregates known to be susceptible to alkali-carbonate reaction (ACR).
   b. Aggregates shall have been tested to determine potential alkali-aggregate reactivity in concrete in accordance with ASTM C260/C260M or ASTM C1567.
      1) Aggregates that indicate expansion greater than 0.10 percent at 16 days after casting shall not be used unless they have been shown to be non-deleteriously reactive in accordance with ASTM C227 or ASTM C1293, with less than 0.04 percent expansion at 1 year for cement-aggregate combinations or less than 0.04 percent expansion at 2 years for combinations with pozzolan or slag.
      2) Alkali content of cement used in proposed concrete mixture shall not be greater than alkali content of cement used in test for potential alkali-aggregate reactivity.
      3) Use low-alkali cement or incorporate pozzolans into concrete mixture as necessary to satisfy testing for potential alkali reactivity.
   c. Use low alkali cement or incorporate pozzolans into the concrete mixture as necessary to satisfy testing for potential alkali reactivity. Alternately, a chemical inhibitor such as a lithium based admixture may be proposed. Submit documentation of control of alkali-aggregate reactivity for proposed admixtures.
3. Proportions: Design mix to meet aesthetic, durability, and strength requirements.
4. NSF/ANSI 61 Concrete Certification: Prior to placement of concrete, the Subcontractor shall submit concrete materials to be used in concrete for hydraulic structures for testing in compliance with NSF/ANSI 61 as indicated below. Test results must be available for approval by Jacobs prior to placement of concrete in hydraulic structures.
   a. Cement shall be NSF/ANSI 61 certified (required only for the Clarifier 2 and Clarifier 3, and Mixer Boxes concrete).
   b. Admixtures shall be NSF/ANSI 61 certified (required only for the Clarifier 2 and Clarifier 3, and Mixer Boxes concrete).

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c. Aggregates shall be tested and approved by one of the following methods:
   1) Provide test cylinders using the proposed mix designs for the concrete that come in direct contact with potable and test as a barrier material per Chapter 5 of NSF/ANSI 61.
d. If NSF/ANSI 61 certified cement and admixtures are not available, the following testing procedures shall be required:
   1. Provide laboratory concrete test cylinders for each mix design that will come in direct contact with potable water to an approved testing laboratory.
   2. Concrete specimens shall be soak-tested to verify water quality is in compliance with NSF/ANSI 61 Chapter 5 – Barrier Materials. Concrete specimens shall be tested for the items listed in NSF/ANSI 61 Table 3.1 – Portland and Hydraulic Cements.
   3. Testing shall be conducted by an ANSI or ELAP accredited product certification body for Drinking Water Quality.

5. Slump Range at Site:
   a. Prior to submitting mix design, consult with concrete producer and select a target slump value at point of delivery, for each application of each design mix. Unless otherwise permitted, target slump value will then be enforced for duration of Project.
   b. Design mixes that include a high-range, water-reducing or a plasticizing admixture shall have a minimum slump of 2 inches prior to addition of admixture. Unless otherwise permitted, slump shall be 8 inches maximum at point of delivery, for concrete with a high-range, water-reducing admixture.
   c. Slump Tolerance: Meet requirements of ACI 117.
6. Combined Aggregate Gradation:
   a. Combined Gradation Limits: Fine aggregate shall be in range of 36 percent to 40 percent of total aggregate weight.

C. Concrete Mixing:

1. General: In accordance with ACI 301, except as modified herein.
2. Truck Mixers:
   a. For every truck, test slump of samples taken per ASTM C94/C94M, Paragraph 12.5.1.
   b. Where specified slump is more than 4 inches, and if slump tests differ by more than 2 inches, discontinue use of truck mixer, unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

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2.04 REINFORCING STEEL

A. Deformed Steel Reinforcing Bars: ASTM A615/A615M, Grade 60. Welding of reinforcing bars is not permitted.

B. Fabrication: Follow CRSI Manual of Standard Practice.

2.05 ANCILLARY MATERIALS

A. Bonding Agent: Unless otherwise specified, in accordance with the following:

1. ASTM C881/C881M, Type V.
2. Two-component, moisture insensitive, 100 percent solids epoxy.
3. Consult manufacturer for surface finish, pot life, set time, vertical or horizontal application, and forming restrictions.
4. Manufacturers and Products:
   a. BASF Building Systems Inc., Shakopee, MN; Concresive Standard LVI.
   b. Euclid Chemical Co., Cleveland, OH; Euco # 352 Epoxy System LV.
   c. Prime Resins, Conyers, GA; Prime Bond 3000 to 3900 Series.
   d. Sika Chemical Corp., Lyndhurst, NJ; Sikadur 32 Hi-Mod.

B. Form Release Agent:

1. Material:
   a. Shall not bond with, stain, or adversely affect concrete surfaces.
   b. Shall not impair subsequent treatments of concrete surfaces when applied to forms.
   c. Ready-to-use water based material formulated to reduce or eliminate surface imperfections.
   d. Contain no mineral oil or organic solvents.
2. Manufacturers and Products: Not for surfaces exposed to potable water.
   a. BASF, Shakopee, MN; MBT MasterFinish RL 211.
   b. Cresset Chemical Company; Crete-Lease 20-VOC-Xtra.
3. Manufacturers and Products: For use with potable water structures. Environmentally safe, meeting local, state, and federal regulations and usable in potable water facilities. Certified as meeting NSF 61.
   a. Atlas Tech Products; Atlas Bio-Guard.
   b. Dayton Superior; Dayton Bio-Release EF.
   c. Hill and Griffith Company; Grifcote LV-50-Plus.

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C. Bond Breaker:

1. Nonstaining type, providing positive bond prevention.
2. Manufacturers and Products:
   a. Dayton Superior Corporation, Kansas City, KS; EDOCO Clean Lift Bond Breaker.
   b. Nox-Crete Products Group, Omaha, NE; Silcoseal Select.

D. Tie Wire:

1. Black, soft-annealed 16-gauge wire.
2. Nylon-, epoxy-, or plastic-coated wire.

E. Bar Supports and Spacers:

1. Use precast concrete bar supports and side form spacers, unless noted otherwise. Do not use other types of supports or spacers.
2. Bar supports shall have sufficient strength and stiffness to carry loads without failure, displacement, or significant deformation. Space bar supports so minimum concrete cover is maintained for reinforcing between supports.

F. Hydrophilic Waterstop:

1. For use at construction joints only, where new concrete is placed against existing concrete and as shown on Drawings.
2. Material shall be a nonbentonite hydrophilic rubber compound.
3. Manufacturers and Products:
   a. Greenstreak Plastic Products, St. Louis, MO; Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive and sealant.
   b. Adeka Ultra Seal, JLM Associates, Spearfish, SD; MC-2010M with 3M-2141 adhesive and P-201 sealant.

G. PLASTIC WATERSTOP

1. Extruded from elastomeric plastic compound of which basic resin shall be prime virgin polyvinyl chloride (PVC). Compound shall not contain scrapped material, reclaimed material, or pigment.
2. Specific Gravity: Approximately 1.37.
3. Type Required in All Expansion, Contraction, and Control Joints: 6 inches wide or 9 inches wide with center bulb and parallel longitudinal ribs or protrusions on each side of strip center, as indicated on Drawings.
4. Corrugated or tapered type waterstops are not acceptable.

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5. Manufacturers and Products for Center Bulb Type:
   a. Vinylex Corp., St Louis, MO.; No. RB638H (6 inches by 3/8 inch) and No. RB938H (9 inches by 3/8 inch).
   b. Greenstreak, St. Louis, MO; Style No. 702, (4 inches by 3/16 inch), Style 732 (6 inches by 3/8 inch) and Style 735 (9 inches by 3/8 inch).

H. Premolded Joint Filler:

1. Bituminous Type: ASTM D994 or ASTM D1751.

I. POURABLE JOINT FILLERS

1. General:
   a. Although product is a sealant, it is being specified as a filler to prevent debris accumulation and allow expansion and contraction under shrinkage and thermal loads. It does not need to meet proportional sealant geometry requirements.
   b. For Potable Water Containment structures, meet requirements of NSF 61.
2. Filler for Potable or Nonpotable Water Containment Structures:
   c. Multicomponent sealant, self-leveling or nonsag as required for level, sloping, or vertical joints.
   d. Color: White.
   e. Manufacturer and Product: Sika Corp., Lyndhurst, NJ; Sikaflex 2c SL.
3. Filler for Nonpotable Water Containment Structures Only:
   f. Pourable, two-component, cold-applied compound meeting ASTM C920, Type M, Grade P, Class 25, Use T.
   g. Color: Black.

J. Joint Sealant:

1. General:
   a. References:
      1) The following is a list of standards which may be referenced in this section:
         a) ASTM International (ASTM):
            (1) C661, Standard Test Method for Indentation Hardness of Elastomeric Type Sealants by Means of a Durometer.
            (2) C834, Standard Specification for Latex Sealants.
            (3) C920, Standard Specification for Elastomeric Joint Sealants.
            (4) C1193, Standard Guide for Use of Joint Sealants.

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2. One-Part Polyurethane, Immersible:
   a. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.
   b. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
   a. Sika Chemical Corp.; Sikaflex 1a.
   b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
   a. Tremco; Vulkem 45.
   b. Sika Chemical Corp.; Sikaflex 1c SL.

K. Curing Compound:

1. Water-based, high-solids content, nonyellowing, curing compound meeting requirements of ASTM C1315 Type I, Class A.
2. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee, MN; Kure 1315.
   b. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
   c. WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
   d. Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315.
   e. Dayton Superior; Safe Cure and Seal 1315 EF.

L. Evaporation Retardant:

1. Optional: Fluorescent fugitive dye color tint that disappears completely upon drying.
2. Manufacturers and Products:
   a. Master Builders Co., Cleveland, OH; Confilm.
   b. Euclid Chemical Co., Cleveland, OH; Eucobar.

M. Nonshrink Grout: In accordance with requirements of Section 03 62 00, Nonshrink Grouting.

N. Repair Material:

1. In accordance with requirements of Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.
2. In accordance with requirements of Section 03 01 33, Repair of Horizontal Concrete Surfaces.

2.06 SOURCE QUALITY CONTROL

A. Source Quality Control Inspection: Engineer shall have access to and have right to inspect batch plants, cement mills, and supply facilities of suppliers, manufacturers, and Subcontractors, providing products included in this section.

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PART 3 EXECUTION

3.01 GENERAL

A. Meet requirements ACI 301, except as modified herein.

3.02 FORMWORK

A. Form Construction:

1. Construct forms and provide smooth-form finish.
2. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
3. Make joints tight to prevent escape of mortar and to avoid formation of fins.
4. Brace as required to prevent distortion during concrete placement.
5. On exposed surfaces locate form ties in uniform pattern or as shown.
6. Construct so ties remain embedded in the member with no metal within 1 inch of concrete surface when forms, inserts, and tie ends are removed.

B. Form Removal:

1. Nonsupporting forms (walls and similar parts of Work) may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:
   a. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
   b. Curing and protection operations are maintained.
2. Remove forms with care to prevent scarring and damaging the surface.
3. Prior to form removal, provide thermal protection for concrete being placed under the requirements of cold weather concreting.

3.03 PLACING REINFORCING STEEL

A. Unless otherwise specified, place reinforcing steel in accordance with CRSI Recommended Practice for Placing Reinforcing Bars.

B. Splices and Laps:

1. Lap Splice Reinforcing: Refer to Structural General Notes on Drawings for additional information.
2. Tie splices with 18-gauge annealed wire as specified in CRSI Standard.

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3.04 INSTALLATION OF WATERSTOPS

A. General:

1. Continuous waterstop (as specified) shall be installed in all construction joints in walls and slabs of water holding basins and channels and in walls of belowgrade structures, unless specifically noted otherwise.
2. Join waterstop at intersections to provide continuous seal.
3. Center waterstop on joint.
4. Secure waterstop in correct position. Do not displace waterstop during concrete placement.
5. Repair or replace damaged waterstop.
6. Place concrete and vibrate to obtain impervious concrete in vicinity of joints.

B. Hydrophilic Waterstop:

1. Install in accordance with manufacturer's written instructions.
2. Provide minimum of 2-1/2 inches of concrete cover over waterstop. When structure has two layers of reinforcing steel, locate centered between layers of steel or as shown.
3. Apply adhesive to concrete surface and allow to dry for specified time before applying waterstop strip.
4. Butt ends of waterstop strip together at splices and corners and join with sealant.
5. Verify that waterstop is anchored firmly in place before placing concrete. Do not allow vibrator to come into contact with waterstop.

3.05 CONCRETE PLACEMENT INTO FORMWORK

A. Inspection: Notify Engineer and Special Inspector at least 1 work day in advance before starting to place concrete.

B. Placement into Formwork:

1. Reinforcement: Secure in position before placing concrete.
2. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep, except for slabs which shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
3. Placement frequency shall be such that lift lines will not be visible in exposed concrete finishes.
4. Use placement devices, for example chutes, pouring spouts, and pumps as required to prevent segregation.

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5. Vertical Free Fall Drop to Final Placement:
   a. Forms 8 Inches or Less Wide: 5 feet.
   b. Forms Wider than 8 Inches: 8 feet, except as specified.
6. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value.
   a. Limit free fall to prevent segregation caused by aggregates hitting steel reinforcement.
7. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.
8. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.

C. Conveyor Belts and Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
2. Do not use chutes longer than 50 feet.
3. Wipe clean with device that does not allow mortar to adhere to belt.
4. Cover conveyor belts and chutes.

D. Retempering: Not permitted for concrete where cement has partially hydrated.

E. Pumping of Concrete:

1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to ensure completion of concrete placement without cold joints in case of primary placing equipment breakdown.
2. Minimum Pump Hose (Conduit) Diameter: 4 inches.
3. Replace pumping equipment and hoses (conduits) that are not functioning properly.

F. Maximum Size of Concrete Placements:

1. Limit size of each placement to allow for strength gain and volume change as a result of shrinkage.
2. Construction Joints:
   a. Unless otherwise shown or permitted, locate construction joints as follows:
      1) Locate construction joints as shown on Drawings or where approved in the joint location submittal.
      2) Provide vertical construction joints at maximum spacing of 40 feet unless shown or approved otherwise.

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3) When vertical expansion, contraction or control joint spacing does not exceed 60 feet, intermediate construction joints are not required.
4) Uniformly space vertical construction joints within straight sections of walls, avoiding penetrations.
5) Intermediate construction joints are not required for concrete fill.

3. Should placement sequence result in cold joint located below finished water surface, install waterstop in joint.

G. Minimum Time between Adjacent Placements:

1. Construction: 7 days.
2. Construction joint between top of footing or slab, and column or wall: As soon as can safely be done without damaging previously cast concrete or interrupting curing thereof, but not less than 24 hours.
3. For columns and walls with a height in excess of 10 feet, wait at least 2 hours before depositing concrete in beams, girders, or slabs supported thereon.
4. For columns and walls 10 feet in height or less, wait at least 1 hour prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon.

3.06 CONSOLIDATION AND VISUAL OBSERVATION

A. Consolidation Equipment and Methods: ACI 301.

B. Provide at least one standby vibrator in operable condition at placement Site prior to placing concrete.

C. Provide sufficient windows in forms or limit form height to allow for concrete placement through windows and for visual observation of concrete.

D. Vibrate concrete in vicinity of joints to obtain impervious concrete.

3.07 COLD WEATHER PLACEMENT

A. Unless otherwise permitted, shall be in accordance with requirements of ACI 306.1 and as follows:

1. Cold weather requirements shall apply when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling.
2. Do not place concrete over frozen earth or against surfaces with frost or ice present. Frozen earth shall be thawed to acceptance of Engineer.

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3. Unless otherwise permitted, do not place concrete in contact with surfaces less than 35 degrees F; requirement is applicable to all surfaces including reinforcement and other embedded items.
4. Provide supplemental external heat as needed when other means of thermal protection are unable to maintain minimum surface temperature of concrete as specified in ACI 306.1.
5. Maintain minimum surface temperature of concrete as specified in ACI 306.1 for no less than 3 days during cold weather conditions.
6. Protect concrete from freezing until end of curing period and until concrete has attained a compressive strength of 3,500 psi or design compressive strength if less than 3,500 psi.

B. Provide maximum and minimum temperature sensors placed on concrete surfaces spaced throughout Work to allow monitoring of concrete surface temperatures representative of Work. Unless otherwise permitted, record surface temperature of concrete at least once every 12 hours during specified curing period.

C. External Heating Units: Do not exhaust heater flue gases directly into enclosed area as it causes concrete carbonation as a result of concentrated carbon dioxide.

D. Cure as specified.

3.08 HOT WEATHER PLACEMENT

A. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 301, ACI 305.1, and as follows:

1. Maintain concrete temperature below 95 degrees F at time of placement, or furnish test data or other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.
2. Internal concrete temperature in structure shall not exceed 158 degrees F, and maximum temperature differential between center of section and external surfaces of concrete shall not exceed 35 degrees F.
3. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.
4. Cure as specified.

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3.09 CONCRETE BONDING

A. Construction Joints at Existing Concrete:

1. Thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 1/4 inch.
2. Saturate surface with water for 24 hours prior to placing new concrete.

3.10 FINISHING FORMED SURFACES

A. Provide surface finish 2.0 (SF-2.0) in accordance with ACI 301 and as herein specified.

B. Tie Holes: Unless otherwise specified, fill with specified repair material.

1. Prepare substrate and mix, place, and cure repair material per manufacturer's written recommendations.

C. Alternate Form Ties, Through-Bolts:

1. Mechanically roughen entire interior surface of through hole.
2. Apply bonding agent to roughened surface and drive elastic vinyl plug to half depth.
3. Dry pack entire hole from both sides of plug with nonshrink grout.
4. Use only enough water to dry pack grout.
5. Dry pack while bonding agent is still tacky.
6. If bonding agent has dried, remove bonding agent by mechanical means and reapply new coat of bonding agent.
7. Compact grout using steel hammer and steel tool to drive grout to high density.
8. Cure grout per grout manufacturer's written recommendations.

D. Repair Defective Areas of Concrete:

1. In accordance with requirements of Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.
2. In accordance with requirements of Section 03 01 33, Repair of Horizontal Concrete Surfaces.

3.11 FINISHING UNFORMED SURFACES

A. General:

1. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.

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2. Do not use “jitterbugs” or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer of mortar, which will be weak and cause surface cracks or delamination, to accumulate.
3. Do not dust surfaces with dry materials nor add water to surfaces.
4. Cure concrete as specified.

B. Interior Slab Finish: Provide trowel finish unless specified otherwise.

C. Exterior Slab Finish:

1. Provide broom finish unless specified otherwise.
2. Finish exposed edges with steel edging tool.
3. Mark sidewalks transversely at 5-foot intervals with jointing tool.

3.12 EXPOSED METAL OBJECTS

A. Remove metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, by chipping back concrete to depth of 1 inch and then cutting or removing metal object.

B. Repair area of chipped-out concrete as specified for defective areas.

3.13 BLOCKOUTS AT PIPES OR OTHER PENETRATIONS

A. Where shown, install in accordance with requirements of Drawings.

3.14 PROTECTION AND CURING

A. Protect fresh concrete from direct rays of sunlight, drying winds, and wash by rain.

B. Keep concrete slabs continuously wet for a 7-day period. Intermittent wetting is not acceptable.

C. Use curing compound only where approved by Engineer. For Clarifier No. 2 and Clarifier No. 3, and Mixer Boxes concrete, water curing method shall be used.

D. Cure formed surfaces with curing compound applied in accordance with manufacturer’s written instructions as soon as forms are removed and finishing is completed.

E. Remove and replace concrete damaged by freezing.

F. Repair areas damaged by construction, using specified repair materials and approved repair methods.

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3.15 BACKFILL AGAINST STRUCTURES

A. Do not backfill against walls until concrete has obtained specified 28-day compressive strength.

B. Refer to General Structural Notes on Drawings for additional requirements, including elevated slab and diaphragm completion prior to backfill.

C. Unless otherwise permitted, place backfill simultaneously on both sides of structure, where such fill is required, to prevent differential pressures.

3.16 FIELD QUALITY CONTROL

A. General:

1. Provide adequate facilities for safe storage and proper curing of concrete test specimens onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
2. Unless otherwise specified, sample concrete for testing for making test specimens, from point of delivery.
3. When concrete is pumped, sample and test air content at point of delivery and at point of placement.
    a. For Each Concrete Mixture: Provided results of air content tests for first load of the day are within specified limits, testing need only be performed at point of delivery for subsequent loads of that concrete mixture except that testing should be performed at point of placement every 4 hours.
4. Evaluation will be in accordance with ACI 301 and Specifications.
5. Test specimens shall be made, cured, and tested in accordance with ASTM C31/C31M and ASTM C39/C39M.
6. Frequency of testing may be changed at discretion of Engineer.
7. Pumped Concrete: Take concrete samples for slump, ASTM C143/C143M, and test specimens, ASTM C31/C31M and ASTM C39/C39M, and shrinkage specimens (ASTM C157/C157M) at placement (discharge) end of line.
8. If measured air content at delivery is greater than specified limit, check test of air content will be performed immediately on a new sample from delivery unit. If check test fails, concrete has failed to meet requirements of Contract Documents. If measured air content is less than lower specified limit, adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If check test of adjusted mixture fails, concrete has failed to meet requirements of Contract Documents. Concrete that has failed to meet requirements of Contract Documents shall be rejected.

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B. Concrete Strength Test:

1. Unless otherwise specified, one specimen at age of 7 days for information, and two 6-inch diameter or when permitted three 4-inch diameter test specimens at age of 28 days for acceptance.
2. Provide a minimum of one spare test specimen per sample. Test spare cylinder as directed by Engineer.

C. High Range Water Reducer (Superplasticizer) Admixture Segregation Test: Test each truck prior to use on Job.

1. Segregation Test Objective: Concrete with 4-inch to 8-inch slump shall stay together when slumped. Segregation is assumed to cause mortar to flow out of mix even though aggregate may stay piled enough to meet slump test.
2. Test Procedure: Make slump test and check for excessive slump and observe to see if mortar or moisture flows from slumped concrete.
3. Reject concrete if mortar or moisture separates and flows out of mix.

D. Cold Weather Placement Tests:

1. During cold weather concreting, cast cylinders for field curing as follows. Use method that will produce greater number of specimens:
   a. Six extra test cylinders from last 100 cubic yards of concrete.
   b. Minimum three specimens for each 2 hours of placing time or for each 100 cubic yards.
2. These specimens shall be in addition to those cast for lab testing.
3. Protect test cylinders from weather until they can be placed under same protection provided for concrete of structure that they represent.
4. Keep field test cylinders in same protective environment as parts of structure they represent to determine if specified strength has been obtained.
5. Test cylinders in accordance with applicable sections of ASTM C31/C31M and ASTM C39/C39M.
6. Use test results to determine specified strength gain prior to falsework removal.

E. Slab Finish Tolerances and Slope Tolerances:

1. Support 10-foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.
2. Compliance with designated limits in four of five consecutive measurements is satisfactory, unless defective conditions are observed.

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3.17 MANUFACTURER'S SERVICES

A. Provide representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and certification of proper installation for concrete ingredients, mix design, mixing, and placement.

B. Concrete Producer Representative:

1. Observe how concrete mixes are performing.
2. Concrete Producer Representative:
    a. Observe how concrete mixes are performing.
    b. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project, including instructions for redosing.
    c. Establish control limits on concrete mix designs.
    d. If redosing of admixtures is acceptable to Concrete Producer, provide equipment for control of redosing, at Site to maintain proper slump and air content if needed.
3. Admixture Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.
4. Bonding Agent Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.

3.18 SUPPLEMENTS

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

1. Concrete Mix Design, Class 5000F3S1P2C2.
2. Concrete Mix Design, Class 4500F1S1P0C1.

END OF SECTION

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CONCRETE MIX DESIGN, CLASS 5000F3S1P2C2

A. Mix Locations: Typical, unless otherwise specified.

B. Exposure Categories and Classifications: F3S1P2C2.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.40.
2. Minimum concrete compressive strength (f'c) shall be 4,000 psi at 28 days and 5,000 psi at 56 days.
3. Air-entraining admixtures are prohibited in concrete mixtures and total air content shall not be greater than 3 percent, for the following:
4. Slabs to receive hard-troweled finish.
5. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in.‡	**Air Content (%)***
¾	6.0
1	6.0
1-1/2	5.5
‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations. *Tolerance of air content is ±1-1/2 percent. §Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.	

6. Limit supplementary cementitious materials measured as a percent of weight of total cementitious materials in mix design, as follows:
   a. 25 percent.

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7. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
   c. ASTM C595/C595M Type IP or Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
      1) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
8. Unless otherwise permitted, minimum cementitious materials content in mix design shall be as follows:
   a. 515 pounds per cubic yard for concrete with 1-1/2-inch nominal maximum size aggregate.
   b. 535 pounds per cubic yard for 1-inch nominal maximum size aggregate.
   c. 560 pounds per cubic yard for 3/4-inch nominal maximum size aggregate.
   d. Unless otherwise permitted, limit cementitious materials content to 100 pounds per cubic yard greater than specified minimum cementitious materials content in mix design.
9. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent, unless otherwise specified.
   a. Limits are stated in terms of chloride ions in percent by weight of cement.
   b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to PART 1 through PART 3 of this section for additional requirements.

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CONCRETE MIX DESIGN, CLASS 4500F1S1P0C1

A. Mix Locations:

1. Sidewalk and curb.
2. Electrical duct banks.
3. Pipe encasements that are not cast monolithically with concrete base mats or slabs.
4. Concrete seal slabs/mud mat.
5. Concrete fill.

B. Exposure Categories and Classifications: F1S1P0C1.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.45.
2. Minimum concrete compressive strength (f'c) shall be 3,000 psi at 28 days.
3. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	**Air Content (%)***
½	5.5
¾	5.0
1	4.5
‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations. *Tolerance of air content is ±1-1/2 percent. §Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on the sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.	

4. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.

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b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
   1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
   2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
   3) ASTM C595/C595M Type IP or Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).

c. Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.

5. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent, unless otherwise specified.
   a. Limits are stated in terms of chloride ions in percent by weight of cement.
   b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to PART 1 through PART 3 of this section for additional requirements.

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SECTION 03 39 00
CONCRETE CURING

PART 1 GENERAL

1.01 REFERENCES

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

1. American Concrete Institute (ACI): 308.1, Specification for Curing Concrete.
2. ASTM International (ASTM):
   a. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   b. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
3. NSF International: 61, Drinking Water System Components – Health Effects.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturers' data indicating compliance with the requirements specified herein for the following products:
   a. Evaporation retardant.
   b. Curing compound.
   c. Clear liquid densifier.
2. Curing methods proposed for each type of element such as slab, walls, beams, and columns in each facility.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
   a. Curing compound showing moisture retention requirements.

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PART 2 PRODUCTS

2.01 MATERIALS

A. Curing Compound:

1. Water-based, high-solids content, nonyellowing, curing compound meeting requirements of ASTM C1315 Type I, Class A.
2. Manufacturers and Products:
   a. Surface not in Contact with Portable Water:
      1) Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
      2) WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
      3) Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315.
   b. Surface in Contact with Portable Water:
      1) Dayton Superior Clear Cure VOC J7WB and Cure Hard J14; Miamisbury, OH 45372.

B. Evaporation Retardant:

1. Optional: Fluorescent fugitive dye color tint that disappears completely upon drying.
2. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee, MN; MasterKure ER 50.
   b. Euclid Chemical Co., Cleveland, OH; Eucobar.

C. Clear Liquid Densifier:

1. Colorless, aqueous solution containing silicate compound.
2. Manufacturer and Product: Euclid Chemical Co., Cleveland, OH; Diamond Hard.

D. Water: Clean and potable, containing less than 500 ppm of chlorides.

PART 3 EXECUTION

3.01 CONCRETE CURING

A. General:

1. Cure all concrete in accordance with project specifications and ACI308.1.

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2. Where surfaces are to receive coatings, painting, cementitious material, or other similar finishes, use only water curing procedures. Refer to Interior Finish Schedule for surfaces to receive coatings.
3. Use only water curing on structures unless approved by the Engineer.
4. If result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing specified below, by 7 additional days.

B. Use one of the following methods as approved by Engineer:

1. Vertical Surfaces
   a. Method 1: Leave concrete forms in place and keep surfaces of forms and concrete wet for 7 days.
   b. Method 2: Continuously sprinkle with water 100 percent of exposed surfaces for 7 days starting immediately after removal of forms.
   c. Method 3: Apply curing compound, where allowed, immediately after removal of forms.
2. Horizontal Surfaces:
   a. Method 1: Protect surface by water ponding for 7 days.
   b. Method 2: Cover with burlap or cotton mats and keep continuously wet for 7 days.
   c. Method 3: Cover with 1-inch layer of wet sand, earth, or sawdust, and keep continuously wet for 7 days.
   d. Method 4: Continuously sprinkle exposed surface for 7 days.
   e. Method 5: Apply curing compound, where allowed, immediately after final finishing when surface will no longer be damaged by traffic.

3.02 EVAPORATION RETARDANT APPLICATION

A. Use on flatwork when environmental conditions are anticipated to cause rapid drying of the concrete surface. Do not use evaporation retardant on potable water structures, unless product is NSF 61 approved.

B. Spray onto surface of fresh flatwork concrete immediately after screeding to react with surface moisture.

C. Reapply as needed to ensure a continuous moist surface until final finishing is completed.

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3.03 CLEAR LIQUID DENSIFIER APPLICATION

A. Before application and with Work above completed, water cure concrete walls and floors for a minimum of 28 days to receive sealer, keep clean, unpainted, and free from membrane curing compounds.

B. Apply liquid densifier evenly, using three coats, allowing 24 hours between coats.

1. First coat 1/3 strength, second coat 1/2 strength, and third coat 2/3 strength, mix with water.
2. Apply each coat so as to remain wet on surface for 15 minutes.
3. Apply approved liquid densifier in accordance with manufacturer's instructions.
4. After final coat is completed and dry, remove surplus liquid densifier from surface by scrubbing and mopping with water.

3.04 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.

B. Provide clear liquid densifier manufacturer's representative to demonstrate proper mixing and application of product.

C. Provide curing compound manufacturer's representative to demonstrate proper application of curing compound to show coverage in one coat.

END OF SECTION

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SECTION 03 62 00
NONSHRINK GROUTING

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. C230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   b. C621, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrinkable).
   c. C939, Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   d. C1107/C1107M, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).

1.02 SUBMITTALS

A. Action Submittals:

1. Product data of grouts.
2. Proposed method for keeping existing concrete surfaces wet prior to placing grout.
3. Forming method for fluid grout placements.
4. Curing method for grout.

B. Informational Submittals:

1. Manufacturer’s Written Instructions:
   a. Adding fiber reinforcing to batching.
   b. Cement-water ratio of grout topping.
   c. Mixing of grout.
2. Manufacturer’s proposed training schedule for grout work.
3. Manufacturer’s Certificate of Compliance:
   a. Grout free from chlorides and other corrosion-causing chemicals.
   b. Nonshrink grout properties of Category II and Category III, verifying expansion at 3 days or 14 days will not exceed the 28-day expansion and nonshrink properties are not based on gas or gypsum expansion.

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4. Statements of Qualification: Nonshrink grout manufacturer's representative.
5. Test Reports:
   a. Test report for 24-hour evaluation of nonshrink grout.
   b. Test results and service report from demonstration and training session.
   c. Field test reports and laboratory test results for field-drawn Samples.

1.03 QUALIFICATIONS

A. Nonshrink Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer. Minimum of 1-year experience that has resulted in successful installation of grouts similar to those for this Project.

B. For grout suppliers not listed herein, provide completed 24-hour Evaluation of Nonshrink Grout Test Form, attached at the end of this section. Independent testing laboratory to certify that testing was conducted within last 18 months.

1.04 GUARANTEE

A. Manufacturer's guarantee shall not contain disclaimer on the product data sheet, grout bag, or container limiting responsibility to only the purchase price of products and materials furnished.

B. Manufacturer guarantees participation with Contractor in replacing or repairing grout found defective as a result of faulty materials, as determined by industry standard test methods.

PART 2 PRODUCTS

2.01 NONSHRINK GROUT SCHEDULE

A. Furnish nonshrink grout for applications in grout category in the following schedule:

Application	Temperature Range	Max. Placing Time	
	40 deg F to 100 deg F	20 Min.	Greater Than 20 Min.
Filling tie holes	I	I	I
Machine bases 25 hp or less	II	II	II

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Application	Temperature Range	Max. Placing Time	
	40 deg F to 100 deg F	20 Min.	Greater Than 20 Min.
Through-bolt openings	II	II	II
Machine bases 26 hp and up	III	III	III
Baseplates and/or soleplates with vibration, thermal movement, etc.	III	III	III

2.02 NONSHRINK GROUT

A. Category I:

1. Nonmetallic and nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Test in accordance with ASTM C1107/C1107M:
   a. Grout shall have flowable consistency.
   b. Flowable for 15 minutes.
4. Grout shall not bleed at maximum allowed water.
5. Minimum strength of flowable grout, 3,000 psi at 3 days, 5,000 psi at 7 days, and 7,000 psi at 28 days.
6. Manufacturers and Products:
   a. BASF Building Systems, Inc., Shakopee, MN; Construction Grout.
   b. Euclid Chemical Co., Cleveland, OH; NS Grout.
   c. Dayton Superior Corp., Kansas City, KS; 1107 Advantage Grout.
   d. US MIX Co., Denver, CO; US Spec MP Grout.
   e. L & M Construction Chemicals, Inc., Omaha, NE; Duragrout.

B. Category II:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.

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4. Test in accordance with ASTM C1107/C1107M:
   a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
   b. Temperatures of 40 degrees F, 80 degrees F, and 100 degrees F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
7. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready-mix truck.
8. Manufacturers and Products:
   a. BASF Building Systems, Inc., Shakopee, MN; Master Flow 928.
   b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.
   c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
   d. Dayton Superior Corp., Kansas City, KS; Sure Grip High Performance Grout.
   e. L & M Construction Chemicals, Inc., Omaha, NE; Crystex.

C. Category III:

1. Metallic and nongas-liberating.
2. Prepackaged aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with ASTM C1107/C1107M:
   a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
   b. Temperatures of 40 degrees F and 100 degrees F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 4,000 psi at 1 day, 5,000 psi at 3 days, and 9,000 psi at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.
8. Manufacturer and Product:
   a. BASF Building Systems, Inc., Shakopee, MN; MasterFlow® 885.
   b. L & M Construction Chemicals, Inc., Omaha, NE; Ferrogrout.

PART 3 EXECUTION

3.01 NONSHRINK GROUT

A. General: Mix, place, and cure nonshrink grout in accordance with grout manufacturer’s representative’s training instructions.

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B. Form Tie Holes: Provide nonshrink grout, Category I and Category II, fill space with dry pack dense grout hammered in with steel tool and hammer.

C. Grouting Machinery Foundations:

1. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material.
2. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts.
3. Form with watertight forms at least 2 inches higher than bottom of plate.
4. Fill space between bottom of machinery base and original concrete in accordance with manufacturer's representative's training instructions.

3.02 FIELD QUALITY CONTROL

A. Evaluation and Acceptance of Nonshrink Grout:

1. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.
2. Perform flow cone and bleed tests, and make three 2-inch by 2-inch cubes for each 25 cubic feet of each type of nonshrink grout used. Use restraining caps for cube molds in accordance with ASTM C1107/C1107M.
3. For large grout applications make three additional cubes and one more flow cone test. Include bleed test for each additional 25 cubic feet of nonshrink grout placed.
4. Consistency: As specified in Article Nonshrink Grout. Grout with consistencies outside range requirements shall be rejected.
5. Segregation: As specified in Article Nonshrink Grout. Grout when aggregate separates shall be rejected.
6. Nonshrink grout cubes shall test equal to or greater than minimum strength specified.
7. Strength Test Failures: Nonshrink grout work failing strength tests shall be removed and replaced.
8. Perform bleeding test to demonstrate grout will not bleed.
9. Store cubes at 70 degrees F.
10. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C1107/C1107M.

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3.03 MANUFACTURER'S SERVICES

A. General:

1. Coordinate demonstrations, training sessions, and applicable Site visits with grout manufacturer's representative.
2. Provide and conduct onsite, demonstration and training sessions for bleed tests, mixing, flow cone measurement, cube testing, application, and curing for each category and type of nonshrink grout.
3. Necessary equipment and materials shall be available for demonstration.

B. Training:

1. Training is required for all Type III grout installations.
2. Grout manufacturer's representative shall train Contractor to perform grout work.
3. Establish location at Site and schedule time for grout manufacturer's demonstration and training session of proposed nonshrink grouts. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, such as, baseplates and tie holes to provide actual on-the-job training.
4. Use minimum of five bags for Category III grout. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make a minimum of six cubes for testing of two cubes at 1 day, 3 days, and 28 days. Use remaining grout for final Work.
5. Training shall include methods for curing grout.
6. Transport test cubes to independent test laboratory and obtain test reports.

3.04 SUPPLEMENT

A. The supplement listed below, following "End of Section," is part of this Specification.

1. 24-hour Evaluation of Nonshrink Grout Test Form and Grout Testing Procedures.

END OF SECTION

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SUPPLEMENT 1

_____
(Test Lab Name)

_____
(Address)

_____
(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

OBJECTIVE: Define standard set of test procedures for an independent testing laboratory to perform and complete within a 24-hour period.

SCOPE: Utilize test procedures providing 24-hour results to duplicate field grouting demands. Intent of evaluation is to establish grout manufacturer's qualifications.

PRIOR TO TEST: Obtain five bags of each type of grout.

1. From intended grout supplier for Project.
2. Five bags of grout shall be of same lot number.

ANSWER THE FOLLOWING QUESTIONS FOR GROUT BEING TESTED FROM LITERATURE, DATA, AND PRINTING ON BAG:

A.	Product data and warranty information contained in company literature and data?	Yes_____ No_____
B.	Literature and bag information meet specified requirements?	Yes_____ No_____
C.	Manufacturer guarantees grout as specified in Article Guarantee?	Yes_____ No_____
D.	Guarantee extends beyond grout replacement value and allows participation with Contractor in replacing and repairing defective areas?	Yes_____ No_____
E.	Water demands and limits printed on bag?	Yes_____ No_____
F.	Mixing information printed on the bag?	Yes_____ No_____
G.	Temperature restrictions printed on bag?	Yes_____ No_____

*Rejection of a grout will occur if one or more answers are noted NO.

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GROUT TESTING PROCEDURES

A. Bagged Material:

1. List lot numbers. _____
2. List expiration date. _____
3. Weigh bags and record weight. _____

Owner's Representative will disqualify grout if bag weights have misstated measure plus or minus 2 pounds by more than one out of five bags. (Accuracy of weights is required to regulate amount of water used in mixing since this will affect properties.)

B. Mixing and Consistency Determination:

1. Mix full bag of grout in 10 gallon pail.
2. Use electric drill with a paddle device to mix grout (jiffy or jiffler type paddle).
3. Use maximum water allowed per water requirements listed in bag instructions.
4. Mix grout to maximum time listed on bag instructions.
5. In accordance with ASTM C939 (flow cone) determine time of mixed grout through the flow cone. _____ seconds
6. Add water to attain 20 to 30 second flow in accordance with ASTM C939.
7. Record time of grout through cone at new water demand. _____ seconds
8. Record total water needed to attain 20 to 30 second flow. _____ pounds
9. Record percent of water. _____ percent

C. When fluid grout is specified and additional water is required beyond grout manufacturer's listed maximum water, ASTM C1107/C1107M will be run at new water per grout ratio to determine whether grout passes using actual water requirements to be fluid. Use new water per grout ratio on remaining tests.

D. Bleed Test:

1. Fill two gallon cans half full of freshly mixed grout at ambient temperatures for each category and at required consistency for each.
2. Place one can of grout in tub of ice water and leave one can at ambient temperature.
3. Cover top of both cans with glass or plastic plate preventing evaporation.
4. Maintain 38 degrees F to 42 degrees F temperature with grout placed in ice and maintain ambient temperature for second container for 1 hour.

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5. Visually check for bleeding of water at 15-minute intervals for 2 hours.

6. Perform final observation at 24 hours.

If grout bleeds a small amount at temperatures specified, grout will be rejected.

E. Extended Flow Time and Segregation Test (for Category II and Category III):

1. Divide the remaining grout into two 3 gallon cans. Place the cans into the 40-degree F and 100-degree F containers and leave for 20, 40, and 60 minutes. Every 20 minutes remove and check for segregation or settlement of aggregate. Use a gloved hand to reach to the bottom of the can, if more than 1/4-inch of aggregate has settled to the bottom or aggregate has segregated into clumps reject the grout.

2. Right after the settlement test mix the grout with the drill mixer for 10 seconds. Take a ASTM C939 flow cone test of grout and record flow time. Maintain this process for 1 hour at ambient temperatures of 40 degrees F and 100 degrees F.

   a. 20 min _____, sec. @ 40 degrees F.

   b. 40 min _____, sec. @ 40 degrees F.

   c. 60 min _____, sec. @ 40 degrees F.

   d. 20 min _____, sec. @ 100 degrees F.

   e. 40 min _____, sec. @ 100 degrees F.

   f. 60 min _____, sec. @ 100 degrees F.

All Category II and Category III grout that will not go through the flow cone with continuous flow after 60 minutes will be disqualified.

_____ _____
Qualified Disqualified

F. 24-hour Strength Test:

1. Using grout left in mixing cans in accordance with ASTM C1107/C1107M for mixing and consistency determination test and for extended time flow test, make minimum of nine cube samples.

2. Store cubes at 70 degrees F for 24 hours.

3. Record average compressive strength of nine cubes at 24 hours.

Grout will be disqualified if 24-hour compressive strengths are less than 2,500 psi for grouts claiming fluid placement capabilities.

Grouts that have not been disqualified after these tests are qualified for use on the Project for the application indicated in Nonshrink Grout Schedule.

_____ _____
Signature of Independent Testing Laboratory Date Test Conducted

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SECTION 03 63 00
CONCRETE DOWELING

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 DEFINITIONS

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

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

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer’s catalog information.

B. Informational Submittals:

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

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4. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.
5. Field Test Reports: Reports documenting ratio checks made for metering and mixing devices where a batch process is used for mixing adhesive.

1.04 QUALITY ASSURANCE

A. Qualifications:

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

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

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

C. Dispose of when:

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

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

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

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5. Disposable, Self-Contained Cartridge System:
   a. Capable of dispensing both components in proper mixing ratio.
   b. Fit into manually or pneumatically operated caulking gun.
6. Mixed Adhesive: Nonsag, light paste consistency with ability to remain in a 1-inch diameter overhead drilled hole without runout.
7. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
8. Potable Water Structures: Adhesive shall be acceptable for use by NSF 61.
9. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; HIT-RE 500-SD (ESR-2322) or HIT-HY 200 (ESR-3187) Adhesive Anchors.
   b. Powers Fasteners, Brewster, NY; Power PURE110+ Epoxy Adhesive Anchor System (ESR-3298).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508).

B. Mixing Nozzles:

1. Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.
2. Nonremovable internal static mixer required to ensure proper blending of components.

C. Reinforcing Dowels: As specified in Section 03 30 10, Structural Concrete.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling Equipment:

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

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

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

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D. Doweling:

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

E. Adhesive:

1. Install in accordance with manufacturer's instructions.
2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.
3. Dispensing, Metering, and Mixing Adhesive Components: Use portable, automatic metering and mixing device or machine capable of maintaining prescribed mix ratio within deviation of 5 percent or less, by volume.

3.02 FIELD QUALITY CONTROL

A. Special Inspection:

1. Special inspection will be performed by the Special Inspector in accordance with ICC ESR requirements.
2. Special Inspector will observe installation in accordance with requirements of the ICC Evaluation Services Report and will submit report containing the following:
   a. Drill bit compliance.
   b. Hole depth and cleanliness.
   c. Product Description: Product name, rod diameter and length.
   d. Adhesive expiration date.
3. Verification of dowel installation in accordance with manufacturer's published instructions.

B. Testing of Automatic Metering and Mixing Devices:

1. Test for Proper Ratio:
   a. Retain small amount of dispensed adhesive for inspection after each time pump is refilled.
   b. Check samples for color change.

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c. Should change in color occur, follow manufacturer's service instructions to obtain proper operation.

2. Frequency of Tests: Make full ratio check after each 100 gallons of adhesive is dispensed or if color of mixed adhesive becomes noticeably darker or lighter.
3. Ratio Check Procedure:
   a. Disconnect dispensing head behind ON/OFF valve.
   b. Place volume containers of required proportions under "B" and "A" component hose ends.
   c. Actuate pump.
   d. Both cups should fill in an equal time to proper volume, thereby verifying proportion ratio by volume.
4. Document timing and results of each ratio check procedure.

END OF SECTION

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SECTION 03 64 23
CRACK REPAIR INJECTION GROUTING

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): T237, Standard Method of Test for Testing Epoxy Resin Adhesive.
2. American National Standards Institute (ANSI).
3. ASTM International (ASTM):
   a. C882, Standard Specification for Test Method for Bond Strength of Epoxy-Resin System Used with Concrete by Slant Shear.
   b. D570, Standard Test Method for Water Absorption of Plastics.
   c. D638, Standard Test Method for Tensile Properties of Plastics.
   d. D648, Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position.
   e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
   f. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.02 DEFINITIONS

A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.

B. Crack Injection: Method of sealing or repairing cracks by injecting a polymer.

C. Large Cracks: Wider than 0.015 inch.

D. Small Cracks: Width equal to 0.015 inch or less.

E. Structural Cracks: Cracks that reduce the capacity of the structural element and are not generally caused by expansion or contraction of the element.

F. Nonstructural Cracks: Cracks that leak but do not reduce the capacity of the structural element and may be caused by expansion or contraction of the element.

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G. Active Cracks: Those cracks for which the mechanism causing the crack is still at work.

H. Chemical Grout: Any grouting material characterized by being a true solution with no particles in suspension. In the context of this Section, the term chemical grout will be further restricted to referring to a flexible polymer such as polyurethane, capable of expanding upon contact with water.

1.03 SUBMITTALS

A. Action Submittals:

1. Physical and chemical properties for epoxy adhesives.
2. Physical and chemical properties for chemical grouts.
3. Technical data for metering, mixing, and injection equipment.
4. Detailed description, locations and photos of proposed injection procedures.

B. Informational Submittals:

1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy adhesives.
2. Installation instructions for repairing cored sample holes with epoxy grout.
3. Manufacturer's Certificate of Compliance: Certified test results for each batch of epoxy adhesive and chemical grout.
4. Statements of Qualification for Epoxy Adhesive and Chemical Grout:
   a. Manufacturer's Site representative.
   b. Injection applicator.
   c. Injection pump operating technician.
5. Epoxy adhesive two component ratio and injection pressure test records for concrete crack repair work.

1.04 QUALITY ASSURANCE

A. Qualifications for Epoxy Injection Staff:

1. Manufacturer's Site Representative:
   a. Capable of instructing successful methods for restoring concrete structures utilizing epoxy injection process.
   b. Understands and is capable of explaining technical aspects of correct material selection and use.
   c. Experienced in the operation, maintenance, and troubleshooting of application equipment.

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2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
   a. Licensed and certified by the product manufacturer.
   b. Minimum 3 years' experience in successful injection for at least 10,000 linear feet of successful crack injection including 2,000 linear feet of wet crack injection to stop water leakage.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Package adhesive material in new sealed containers and label with following information:

1. Manufacturer's name.
2. Product name and lot number.
3. ANSI Hazard Classification.
4. ANSI recommended precautions for handling.
5. Mix ratio by volume.

B. Storage and Protection: Store adhesive containers at ambient temperatures below 110 degrees F and above 45 degrees F.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. Epoxy Adhesive:
   a. BASF Building Systems, Shakopee, MN; SCB Concresive Series.
   b. Sika Corp., Lyndhurst, NJ; Sikadur Series.
   c. Euclid Chemical Co., Cleveland, OH; Euco Series.
2. Chemical Grout:
   a. Prime Resins, Conyers, GA.
   b. De neef Construction Chemicals, Houston, TX.
   c. Avanti Grout, Webster, TX.

2.02 EPOXY ADHESIVE

A. Two-component A and B structural epoxy adhesive for injection into cracks or other voids in concrete structures for bonding or grouting.

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B. Adhesive Properties:

	Test Method	
7-day, Tensile Strength, psi	ASTM D638	5,000 min.
Tensile Elongation @ Break, percent	ASTM D638	1.0% min.
Compressive Yield Strength, 7 days @ 73°F, psi	ASTM D695[a]	8,000 min.
Compressive Modulus, psi	ASTM D695[a]	$1.5x10^5$ min.
Heat Deflection Temperature, °F	ASTM D648[a]	120 min.[a]
Water absorption @ 24 hours, Maximum %	ASTM D570	1.0
Bond Strength @ 2 days psi	ASTM C882	1,000 min.
Bond Strength @ 14 days psi	ASTM C882	1,500 min.
Slant Shear Strength: (5,000 psi Compressive Strength Conc.) *Where test results are available psi.*	AASHTO T237[b]	
Cured 3 days @ 40 deg F—Wet Concrete		3,500 min.
Cured 1 day @ 77 deg F—Dry Concrete		5,000 min.
Cured 3 days @ 77 deg ± 3 deg F		5,000 min.

[a]Cure test specimens so that peak exothermic temperature of adhesive does not exceed 100°F.

[b]See referenced specifications for preparation method of test specimens.

2.03 CHEMICAL GROUT

A. Hydrophobic or hydrophilic, liquid polyurethane resin for sealing cracks in concrete structures by injection.

B. Grout Properties:

1. Tensile strength in accordance with ASTM D3574.
2. Elongation in accordance with ASTM D3574.
3. Shrinkage in accordance with ASTM D1054/D756.
4. Minimum expansion when contacted by water 400 percent.

2.04 SURFACE SEAL

A. Sufficient strength and adhesion for holding injection fittings firmly in place, and to resist pressures preventing leakage during injection.

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B. Capable of removal after injection adhesive has cured.

2.05 SOURCE QUALITY CONTROL

A. Test Requirements: Perform tests for each batch of epoxy adhesive.

B. Pot Life Test for Epoxy Adhesive:

1. Condition Components A and B to required temperature.
2. Measure components in ratio of Component B as stated on manufacturer's label into an 8-fluid ounce paper cup.
3. Start stopwatch immediately and mix components for 60 seconds using wooden tongue depressor, take care to scrape sides and bottom of cup periodically.
4. Probe mixture once with tongue depressor every 30 seconds, starting 2 minutes prior to minimum specified pot life.
5. Pot Life Definition: Time at which a soft stringy mass forms in center of cup.

C. Fabrication of Slant Shear Specimens for Testing Bond of Injectable Epoxy Adhesives to Wet Concrete at 40 Degrees F:

1. Scope: Test method for preparation of diagonal concrete mortar blocks used in determining slant shear strength of low viscosity injectable adhesives in accordance with AASHTO T237 when concrete is wet.
2. Materials:
   a. Diagonal concrete mortar blocks prepared in accordance with AASHTO Test Method T237 and cured to produce a mortar with compressive strength of 5,000 psi or greater.
   b. Paraffin wax.
   c. Masking Tape: 3/4 inch wide.
   d. Suitable 20-mil-thick shim stock.
3. Preparation:
   a. Place a 20-mil shim between diagonal faces of two blocks and align so ends and sides are square.
   b. Bind block with masking tape covering gap between blocks.
   c. Leave a gap between blocks on one face uncovered for removal of shim and application of adhesive.
   d. Paint melted paraffin wax over masking tape.
   e. Shallow dam may be built up around opening using paraffin wax or modeling clay to help retain adhesive.
   f. Apply suitable capping compound to each end of specimen producing smooth surfaces perpendicular to longitudinal axis of block.

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g. Remove shim stock from gap opening.
h. Soak specimen in water at 40 degrees F, plus or minus 3 degrees F for at least 24 hours.
i. After soaking, remove specimen, shake free water from surface and gap opening.
j. Prepare liquid adhesive.
k. Within 5 minutes after removing specimen from water, start flowing adhesive into crack without entrap air bubbles.
l. Place specimen in 40 degrees F, plus or minus 3 degrees F ambient for curing within 15 minutes after removing specimen from water for bonding. Do not expose specimen to temperatures beyond 77 degrees F during the 15-minute period.
m. Cure specimen for 72 hours, plus or minus 4 hours at 40 degrees F, plus or minus 3 degrees F.

PART 3 EXECUTION

3.01 GENERAL

A. Repair cracks in new structures as specified in Section 03 30 10, Structural Concrete.

B. Repair cracks in existing concrete structures where shown on Drawings.

1. Floor joints in each basin. Three transverse and four longitudinal. Total six transverse and eight longitudinal.
2. Visible cracks on the interior wall surfaces of the flocculator drive pit.
3. Cracks where visual evidence exists of leakage around flocculator drive shaft penetrations through the drive pit walls.

C. Cracks:

1. Repair structural cracks by injection of epoxy adhesive.
2. Repair nonstructural cracks by injection of epoxy adhesive or chemical grout.

3.02 PREPARATION

A. Free cracks from loose matter, dirt, laitance, oil, grease, salt, previous crack repair material on the concrete surface, and other contaminants.

B. Clean cracks in accordance with injection product manufacturer’s instructions.

C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system.

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D. Do not use acids and corrosives for cleaning, unless neutralized prior to injecting.

3.03 APPLICATION

A. Sealing: Apply surface seal in accordance with manufacturer's instructions to designated crack face prior to injection. Seal surface of crack to prevent escape of injection product.

B. Entry Ports:

1. Establish openings for product entry in surface seal along crack.
2. Determine space between entry ports equal to thickness of concrete member to allow product to penetrate to the full thickness of the wall.
3. Provide a means to prevent concrete dusts and fines from contaminating the crack or ports when drilling.
4. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of product to soil at locations where:
   a. Cracks extend entirely through wall.
   b. Backfill exists on one side of wall.
5. Core drill to verify product depth where only one side of wall is exposed.

C. Epoxy Injection:

1. Store epoxy at minimum of 70 degrees F.
2. Start injection into each crack at lowest elevation entry port.
3. Continue injection at first port until adhesive begins to flow out of port at next highest elevation.
4. Plug first port and start injection at second port until adhesive flows from next port.
5. Inject entire crack with same sequence.

D. Finishing:

1. Cure epoxy adhesive after cracks have been completely filled to allow surface seal removal without draining or runback of epoxy material from cracks.
2. Remove surface seal from cured injection adhesive.
3. Finish crack face flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports are not acceptable.
5. Remove surface seal material and injection adhesive runs and spills from concrete surfaces.

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3.04 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter and mix two adhesive components, and inject mixture into crack.

B. Pumps:

1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
2. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
3. Capable of immediate compensation for changes in resins.
4. Do not use batch mix pumps.

C. Discharge Pressure: Automatic pressure controls capable of discharging mixed adhesive at pressures up to 200 psi, plus or minus 5 percent, and able to maintain pressure.

D. Automatic Shutoff Control: Provide sensors on both Component A and B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

E. Proportioning Ratio Tolerance: Maintain epoxy adhesive manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 psi.

F. Ratio/Pressure Check Device:

1. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
2. Pressure gauge capable of sensing pressure behind each valve.

3.05 FIELD QUALITY CONTROL

A. Epoxy Adhesive Two Component Ratio Tests:

1. Disconnect mixing head and pump two adhesive components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 psi for both adhesive components.
3. Simultaneously discharge both adhesive components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.

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6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1 hour.
7. Document and maintain complete accurate records of, ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two adhesive component delivery lines to pressure check device.
2. Pressure Check Device:
   a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
   b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
   a. Beginning and end of each injection work day.
   b. When injection work as stop for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

END OF SECTION

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SECTION 05 05 23
WELDING

PART 1 GENERAL

1.01 REFERENCES

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

1. American Society of Mechanical Engineers (ASME):
   a. BPVC SEC V, Nondestructive Examination.
   b. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.
3. American Welding Society (AWS):
   a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
   b. A3.0, Standard Welding Terms and Definitions.
   c. D1.1/D1.1M, Structural Welding Code - Steel.
   d. D1.2/D1.2M, Structural Welding Code - Aluminum.
   e. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
   f. QC1, Standard for AWS Certification of Welding Inspectors.
4. ASTM International (ASTM): A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

1.02 DEFINITIONS

A. CJP: Complete Joint Penetration.

B. CWI: Certified Welding Inspector.

C. MT: Magnetic Particle Testing.

D. NDE: Nondestructive Examination.

E. NDT: Nondestructive Testing.

F. PJP: Partial Joint Penetration.

G. PQR: Procedure Qualification Record.

H. PT: Liquid Penetrant Testing.

I. RT: Radiographic Testing.

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J. UT: Ultrasonic Testing.

K. VT: Visual Testing.

L. WPQ: Welder/Welding Operator Performance Qualification.

M. WPS: Welding Procedure Specification.

1.03 SUBMITTALS

A. Shop Drawings:

1. Shop and field WPSs and PQRs.
2. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.
3. Welding Data (Shop and Field): Submit welding data together with Shop Drawings as a complete package.
   a. Show on Shop Drawings or a weld map complete information regarding base metal specification designation, location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tails of combined welding and NDE symbols as indicated in AWS A2.4.
   b. Distinguish between shop and field welds.
   c. Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
   d. For pipe fittings, provide a joint weld beveling diagram. Refer to AWS D1.1/D1.1M, Annex P Local Dihedral Angle that can be used to calculate bevels for weld joint details of intersecting pipes.
   e. Welding and NDE symbols shall be in accordance with AWS A2.4.
   f. Welding terms and definitions shall be in accordance with AWS A3.0.

B. Informational Submittals:

1. WPQs.
2. CWI credentials.
3. Testing agency personnel credentials.
4. CWI reports.
5. Welding Documentation: Submit on forms in referenced welding codes.

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1.04 QUALIFICATIONS

A. WPSs: In accordance with AWS D1.1/D1.1M (Annex N Forms) for shop or field welding; or ASME BPVC SEC IX (Forms QW-482 and QW-483) for shop welding only.

B. WPQs: In accordance with AWS D1.1/D1.1M (Annex N Forms); or ASME BPVC SEC IX (Form QW-484).

C. CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.05 SEQUENCING AND SCHEDULING

A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. CWI shall be present whenever shop welding is performed. CWI shall perform inspection, as necessary, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verifying conformance of specified job material and proper storage.
2. Monitoring conformance with approved WPS.
3. Monitoring conformance of WPQ.
4. Inspecting weld joint fit-up and performing in-process inspection.
5. Providing 100 percent visual inspection of welds.
6. Supervising nondestructive testing personnel and evaluating test results.
7. Maintaining records and preparing report confirming results of inspection and testing comply with the Work.

PART 3 EXECUTION

3.01 GENERAL

A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

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3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

A. Weld Inspection Criteria:

1. Selection of welds to be tested, unless 100 percent NDT is specified herein, shall be as agreed upon between Engineer and Contractor.
2. Unless otherwise specified, perform NDT of welds at a frequency as shown below and in the attached Table in accordance with referenced welding codes as follows. Perform UT on CJP groove welds that cannot be readily radiographed. In case there is a conflict, higher frequency level of NDT shall apply.
   a. CJP Groove, Butt Joint Welds: 10 percent random RT.
   b. All other CJP Groove Welds: 10 percent random UT.
   c. Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
   d. All Welds: 100 percent VT.
3. Weld Acceptance:
   a. VT:
      1) Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Tubular Connections.
      2) All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
      3) Stud Connections: AWS D1.1/D1.1M, Paragraph 7.8.1.
   b. UT: Perform on CJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.13.3, Class R Indications.
   c. RT: Perform on CJP butt joint welds in accordance with AWS D1.1/D1.1M, Paragraph 6.12.1.
   d. PT or MT:
      1) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.10.
      2) Acceptance shall be in accordance with VT standards specified above.

3.03 FIELD QUALITY CONTROL

A. CWI shall be present whenever field welding is performed. CWI shall perform inspection, as necessary, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job material and proper storage.
2. Monitor conformance with approved WPS.
3. Monitor conformance of WPQ.

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4. Inspect weld joint fit-up and perform in-process inspection.
5. Provide 100 percent visual inspection of all welds.
6. Supervise nondestructive testing personnel and evaluating test results.
7. Maintain records and prepare report confirming results of inspection and testing comply with the Work.

3.04 WELD DEFECT REPAIR

A. Repair and retest rejectable weld defects until sound weld metal has been deposited in accordance with appropriate welding codes.

3.05 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this Specification.

1. Welding and Nondestructive Testing Table.

END OF SECTION

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Welding and Nondestructive Testing						
Specification Section	**Governing Welding Codes or Standards**	**Submit WPS**	**Submit WPQ**	**Onsite CWI Req'd**	**Submit Written NDT Procedure Specifications**	**NDT Requirements**
05 50 00, Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code–Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum or AWS D1.6/D1.6M, Structural Welding Code - Stainless Steel	No	Yes	Yes	No	100% VT; also see Section 05 50 00
05 52 16, Aluminum Gratings	AWS D1.2/D1.2M, Structural Welding Code - Aluminum	No	No	No	No	100% VT; also see Section 05 52 16, Aluminum Gratings
05 53 00, Metal Gratings	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum	No	No	No	No	100% VT; also see Section 05 53 00
44 44 57, Parallel Plate Settler System	ASME BPV Code, Section IX; and AWS D1.6/D1.6M, Structural Welding Code – Stainless Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 44 44 57

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SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

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

1. The Aluminum Association, Inc. (AA): The Aluminum Design Manual.
2. American Galvanizers Association (AGA):
   a. Inspection of Hot-Dip Galvanized Steel Products.
   b. Quality Assurance Manual.
3. American Iron and Steel Institute (AISI): Stainless Steel Types.
4. American Ladder Institute (ALI): A14.3, Ladders - Fixed - Safety Requirements.
5. American National Standards Institute (ANSI).
6. American Society of Safety Engineers (ASSE): A10.11, Safety Requirements for Personnel and Debris Nets.
7. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code - Steel.
   b. D1.2/D1.2M, Structural Welding Code - Aluminum.
   c. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
8. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Specification for Gray Iron Castings.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   d. A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
   e. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   f. A143/A143M, Standard for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   g. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

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j. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
k. A276, Standard Specification for Stainless Steel Bars and Shapes.
l. A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
m. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
n. A325, Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
o. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
p. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
q. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
r. A489, Standard Specification for Carbon Steel Lifting Eyes.
s. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
t. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
u. A563, Standard Specification for Carbon and Alloy Steel Nuts.
v. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
w. A780/A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
x. A786/A786M, Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates.
y. A793, Standard Specification for Rolled Floor Plate, Stainless Steel.
z. A967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
aa. A992/A992M, Standard Specification for Structural Steel Shapes.
bb. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
cc. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
dd. B429/B429M, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.

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ee. B632/B632M, Standard Specification for Aluminum-Alloy Rolled Tread Plate.
ff. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
gg. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
hh. F436, Standard Specification for Hardened Steel Washers.
ii. F468, Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
jj. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
kk. F594, Standard Specification for Stainless Steel Nuts.
ll. F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
mm. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

9. International Code Council Evaluation Service (ICC-ES):
   a. AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.
   b. AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.
   c. AC70, Acceptance Criteria for Fasteners Power-driven into Concrete, Steel and Masonry Elements.
10. NSF International (NSF): 61, Drinking Water System Components—Health Effects.
11. Occupational Safety and Health Administration (OSHA): 29 CFR 1910.27, Fixed Ladders.
12. Specialty Steel Industry of North America (SSINA):
    a. Specifications for Stainless Steel.
    b. Design Guidelines for the Selection and Use of Stainless Steel.
    c. Stainless Steel Fabrication.
    d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Anchor Bolt: Cast-in-place anchor; concrete.

B. Concrete Anchor: Post-installed concrete anchors listed in this specification.

C. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

D. Exterior Area: Location not protected from weather by building or other enclosed structure.

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E. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.

F. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

G. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Metal fabrications, including welding and fastener information.
   b. Specific instructions for concrete anchor installation, including drilled hole size, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

1. Concrete Post-Installed Anchors:
   a. Manufacturer’s product description and printed installation instructions.
   b. Current ICC-ES Report for each type of post-installed anchor to be used.
   c. Adhesive Anchor Installer Certification.
2. Pre-Engineered Ladders: Letter of certification that ladder meets OSHA 29 CFR 1910.27 requirements.
3. Passivation method for stainless steel members.
4. Galvanized coating applicator qualifications.
5. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer, with description of material processed and ASTM standard used for coating.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Adhesive Anchor Installer: Trained to install adhesive anchors in accordance with manufacturer's printed installation instructions.
2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Insofar as practical, factory assemble specified items. Assemblies, because of necessity, have to be shipped unassembled shall be packaged and tagged in manner that will protect materials from damage and will facilitate identification and field assembly.

B. Package stainless steel items in a manner to provide protection from carbon impregnation.

C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.

D. Store fabricated items in dry area, not in direct contact with ground.

E. Store adhesives anchors at service temperature ranges recommended by manufacturer.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following extra materials:

Item	Quantity
Neoprene Gasket	Two for each location requiring neoprene gaskets.
Neoprene Gasket Adhesive	One (manufacturer's recommended) for each location requiring neoprene gaskets.

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

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PART 2 PRODUCTS

2.01 GENERAL

A. For hot-dip galvanized steel that is exposed to view and does not receive paint, limit the combined phosphorus and silicon content to 0.04 percent. For steels that require a minimum of 0.15 percent silicon (such as plates over 1.5 inches thick for ASTM A36/A36M steel), limit maximum silicon content to 0.21 percent and phosphorous content to 0.03 percent.

B. All aluminum members shall be anodized.

C. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M
Steel Pipe	A500 Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (316L for welded connections)
Shapes	A276, AISI Type 316 (316L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Condition CW
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A563 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 55, with weldability supplement S1.
Eyebolts	A489

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Item	ASTM Reference
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe:	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D
Welded Anchor Studs	A108, Grades C-1010 through C-1020
Aluminum Plates and Structural Shapes	B209 and B308/B308M, Alloy 6061-T6
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

D. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-In-Place Anchor Bolts:

1. Headed type, unless otherwise shown on Drawings.
2. Material type and protective coating as shown in Fastener Schedule at end of this section.

B. Anchor Bolt Sleeves:

1. Plastic:
   a. Single unit construction with corrugated sleeve.
   b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
   c. Material: High-density polyethylene.
   d. Manufacturer: Sinco Products, Inc., Middletown, CT, (800) 243-6753.
2. Fabricated Steel: ASTM A36/A36M.

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2.03 POST-INSTALLED CONCRETE ANCHORS

A. General:

1. AISI Type 316 stainless, hot-dip galvanized, or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Current ICC-ES Report indicating acceptance per IBC 2015 for anchors at structural applications in cracked concrete.
3. Anchors shall be suitable for long-term loads, as well as for wind and seismic loads.
4. Acceptable for use in potable water structures by EPA and local health agencies or NSF 61.
5. Torque-Controlled Expansion Anchors (Wedge Anchors):
   a. Wedge anchors used in sustained tension applications (such as overhead or cantilevered applications) shall have current ICC-ES Report that demonstrates compliance with ICC-ES AC193 for cracked concrete.
   b. Manufacturers and Products:
      1) ITW Ramset/Red Head, Addison, IL; Trubolt+ Wedge Anchor (ESR-2427).
      2) Hilti, Inc., Tulsa, OK; Kwik-Bolt–TZ (KB-TZ) Anchors (ESR-1917).
      3) Powers Fasteners, Brewster , NY; Power-Stud +SD2 or +SD1 Anchors (ESR-2502 and ESR-2818).
      4) Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt Anchors (ESR-1771).
      5) Wej-It Corp., Tulsa, OK; ANKRtite CCAT Wedge Anchor (ESR-2777).
6. Displacement-Controlled Expansion Anchors (Drop-in Anchors):
   a. Self-drilling anchors, snap-off or flush type, zinc-plated.
   b. Nondrilling Anchors: Flush type for use with zinc-plated or stainless steel bolt, or stud type with projecting threaded stud.
   c. Manufacturers and Products:
      1) ITW Ramset/Red Head, Addison, IL; Multi-Set II Drop-In and Self Drill Anchor.
      2) Hilti, Inc., Tulsa, OK; Hilti HDI Drop-In Anchor.
      3) Powers Fasteners, Brewster, NY; Steel Drop-In Anchor.
      4) Simpson Strong-Tie Co., Inc., Pleasanton, CA; Drop-In Anchor.

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7. Undercut Anchors:
   a. When used in sustained tension applications (such as overhead or cantilevered applications) shall have current ICC-ES Report that demonstrates compliance with ICC-ES AC193 for cracked concrete.
   b. Manufacturers and Products:
      1) USP Structural Connectors, Burnsville, MN; DUC Undercut Anchor (ESR-1970).
      2) Hilti, Inc., Tulsa, OK; HDA Undercut Anchor (ESR-1546).
      3) Powers Fasteners, Brewster, NY; Atomic+ Undercut (ESR-3067).
      4) Simpson Strong-Tie Co., Inc., Pleasanton, CA; Torq-Cut (ESR pending).
8. Self-Tapping Concrete Screw Anchors:
   a. When used in sustained tension applications (such as overhead or cantilevered applications) shall have current ICC-ES Report that demonstrates compliance with ICC-ES AC193 for cracked concrete.
   b. Manufacturers and Products:
      1) Powers Fasteners, Brewster, NY; Wedge-Bolt+ (ESR-2526).
      2) Powers Fasteners, Brewster, NY; Vertigo+ Rod Hanger Screw Anchor (ESR-2989).
      3) Powers Fasteners, Brewster, NY; Snake+ Flush Mount Screw Anchor (ESR-2272).
      4) Hilti, Inc., Tulsa, OK; HUS-EZ Screw Anchor (ESR-3027).
      5) Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).
9. Light-Duty Torque Controlled Expansion Anchors (Sleeve Anchors):
   a. Manufacturers and Products:
      1) ITW Ramset/Red Head, Addison, IL; Dynabolt Hex Nut Sleeve Anchor.
      2) Powers Fasteners, Brewster, NY; Lok-Bolt AS.
      3) Simpson Strong-Tie Co., Inc., Pleasanton, CA; Sleeve-All Hex Head Anchor.
      4) Wej-It Corp., Tulsa, OK; Wej-It Sleeve Anchor.
10. Heavy-Duty Torque Controlled Expansion Anchors (Sleeve Anchors):
    a. Manufacturers and Products:
       1) Powers Fasteners, Brewster, NY; Power-Bolt+ Anchor.
       2) Hilti, Inc., Tulsa, OK; HSL-3 Heavy Duty Sleeve Anchor.

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B. Adhesive Anchors (Epoxy Anchors):

1. If approved by Engineer, adhesive anchors used in sustained tension applications (such as overhead or cantilevered applications) shall have current ICC-ES Report that demonstrates compliance with ICC-ES AC308 for cracked concrete.
2. Threaded Rod:
   a. ASTM F593 stainless steel threaded rod, diameter as shown on Drawings.
   b. Length as required, to provide minimum depth of embedment.
   c. Clean and free of grease, oil, or other deleterious material.
   d. For hollow-unit masonry, provide galvanized or stainless steel wire cloth screen tube to fit threaded rod.
3. Adhesive:
   a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
   b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
   c. Mixed Adhesive: Nonsag light paste consistency with ability to remain in 1-inch diameter overhead drilled hole without runout.
   d. Meet requirements of ASTM C881/C881M.
4. Packaging and Storage:
   a. Disposable, self-contained cartridge system capable of dispensing both components in proper mixing ratio and fitting into manually or pneumatically operated caulking gun.
   b. Store adhesive cartridges and adhesive components on pallets or shelving in covered storage area.
   c. Container Markings: Include manufacturer’s name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
   d. Dispose of when:
      1) Shelf life has expired.
      2) Stored other than in accordance with manufacturer’s instructions.
5. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System, HIT RE 500 SD (ESR-2322).
   b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508).
   c. Powers Fasteners, Brewster NY, PE1000+ Adhesive anchoring system (ESR-2583).

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C. Adhesive Threaded Inserts:

1. Stainless steel, internally threaded inserts.
2. Manufacturer and Product: Hilti, Inc., Tulsa, OK; HIS-RN Insert with HIT-RE 500-SD adhesive.

2.04 STUD SHEAR CONNECTORS

A. Headed anchor studs (HAS) as indicated on Drawings.

1. Stainless Steel: ASTM F593, AISI Type 316, Condition CW, where indicated.

B. Manufacturers:

1. Nelson Stud Welding, FabriSteel Co., Elyria, OH.
2. Stud Welding Associates, Inc., Elyria, OH.

2.05 PIPE SLEEVES

A. ASTM A53/A53M, Schedule 40 steel pipe sleeves with continuously welded 3/16-inch-thick seep ring with outside diameter 3 inches greater than sleeve outside diameter. Hot-dip galvanize in accordance with ASTM A123/A123M.

2.06 EMBEDDED STEEL SUPPORT FRAMES FOR GRATING

A. Steel angle support frames to be embedded in concrete shall be stainless steel, ASTM A276, AISI Type 316, unless indicated otherwise.

B. Welded anchors for stainless steel support frames shall also be stainless steel.

2.07 ABRASIVE NOSING FOR STAIRS

A. Unless otherwise shown on Drawings, furnish flush type abrasive nosings on stairs.

B. Nosing Components:

1. Homogeneous epoxy abrasive, with minimum 50 percent aluminum oxide content, formed and cured upon an extruded aluminum base.
2. Epoxy abrasive shall extend over and form curved front edge of nosing.
3. Base of Nosing: Extruded aluminum alloy, 6063-T5, heat-treated.

C. Anchoring System: Double-set anchors consisting of two rows of integrally extruded anchors.

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D. Size: 3 inches wide by 1/4 inch to 3/8 inch thick by length as shown.

E. Color: Selected by Engineer from manufacturer's standard color range.

F. Manufacturers and Products:

1. Wooster Products, Inc., Wooster, OH; Spectra Type WP3C.
2. American Safety Tread Co., Inc., Helena, AL; Type FA-311D.

2.08 LADDERS

A. Fabricate ladders with rails, and rungs to meet applicable requirements of OSHA, CFR Part 1910.27, and ALI A14.3.

1. Concentrated load of 200 pounds loads imposed by persons occupying ladder shall be considered to be concentrated at such points as will cause maximum stress in structural member being considered.
2. Weight of ladder and attached appurtenances together with live load shall be considered in design of rails and fastenings.

B. Flat Bar Ladder:

1. Punch rails, pass rungs through rails, and weld on outside.
2. Weld brackets to ladder for fastening ladder to wall.
3. ASTM A276, AISI Type 316L stainless steel.

2.09 FABRICATED UNITS

A. T-Handled Operating Wrenches: Galvanized operating wrenches, 4-foot total length, No. A-2461 as manufactured by Mueller.

B. Valve Operator Access Box: Cast iron, 8 inches by 4 inches, as manufactured by Zurn; No. ZN-1930-K.

2.10 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
   a. Bostik, Middleton, MA; Neverseez.
   b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.

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B. Neoprene Gasket:

1. ASTM D1056, 2C1, soft, closed-cell neoprene gasket material, suitable for exposure to sewage and sewage gases, unless otherwise shown on Drawings.
2. Thickness: Minimum 1/4 inch.
3. Furnish without skin coat.
4. Manufacturer and Product: Monmouth Rubber and Plastics Corporation, Long Branch, NJ; Durafoam DK1111LD.

2.11 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Steel To Be Hot-dip Galvanized: Limit silicon content to less than 0.04 percent or to between 0.15 and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures–Allowable Stress Design.

C. Welding:

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.
6. Welded Anchor Studs: Prepare surface to be welded and weld with stud welding gun in accordance with AWS D1.1/D1.1M, Section 7, and manufacturer’s instructions.
7. Complete welding before applying finish.

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D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09 90 00, Painting and Coating, unless otherwise indicated.
2. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.

E. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.
2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385/A385M.
3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.
5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
7. Galvanized steel sheets in accordance with ASTM A653/A653M.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

F. Electrolytic Protection: Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

G. Watertight Seal: Where required or shown, furnish neoprene gasket of a type that is satisfactory for exposure condition. Cover full bearing surfaces.

H. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.

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I. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.12 SOURCE QUALITY CONTROL

A. Visually inspect all fabrication welds and correct deficiencies.

1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
2. Aluminum: AWS D1.2/D1.2M.
3. Stainless Steel: AWS D1.6/D1.6M.

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

A. General:

1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
2. Install rigid, substantial, and neat in appearance.
3. Install manufactured products in accordance with manufacturer's recommendations.
4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.

B. Aluminum:

1. Do not remove mill markings from concealed surfaces.
2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

C. Pipe Sleeves:

1. Provide where pipes pass through concrete or masonry.
2. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls.
3. Provide center flange for water stoppage on sleeves in exterior or water-bearing walls.
4. Provide rubber caulking sealant or a modular mechanical unit to form watertight seal in annular space between pipes and sleeves.

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3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Locate and hold anchor bolts in place with templates at time concrete is placed.

B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.

C. Minimum Bolt Size: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 CONCRETE POST-INSTALLED ANCHORS

A. Begin installation only after concrete to receive anchors has attained design strength.

B. Install in accordance with manufacturer's instructions.

C. Provide minimum embedment, edge distance, and spacing as follows, unless indicated otherwise by anchor manufacturer's instructions or shown otherwise on Drawings:

Anchor Type	Minimum Embedment (Bolt Diameters)	Minimum Edge Distance (Bolt Diameters)	Minimum Spacing (Bolt Diameters)
Expansion	9	6	12
Undercut	9	12	16
Adhesive	9	9	13.5

D. Use only drill type and bit type and diameter recommended by anchor manufacturer. Clean hole of debris and dust with brush and compressed air per manufacturer's printed installation instructions.

E. For undercut anchors, use special undercutting drill bit and rotary hammer drill and apply final torque as recommended by anchor manufacturer.

F. When embedded steel or rebar is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than 10 degrees to clear obstruction, notify Engineer for direction on how to proceed.

G. Adhesive Anchors:

1. Do not install adhesive anchors when temperature of concrete is below 40 degrees F or above 100 degrees F, unless cold temperature adhesives,

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compliant with ACI 308 are used. Refer to the respective ICC-ES report and manufacturer's printed installation instructions.

2. Remove water from hole with oil-free compressed air. Damp or water filled holes may be allowed only if approved in manufacturer's printed installation instructions and ICC-ES report.
3. Do not disturb anchor during recommended curing time.
4. Do not exceed maximum torque as specified in manufacturer's printed installation instructions.

H. Prestressed Concrete: Do not use post-installed anchors in prestressed or post-tensioned concrete members without Engineer's prior approval, unless specifically shown on Drawings. If Engineer approves anchor installation all prestressed tendons in vicinity of anchors must be located prior to drilling.

3.04 ABRASIVE NOSINGS

A. Provide abrasive nosings on concrete steps not being supplied or coated with another type of nosing or nonskid material.

3.05 ELECTROLYTIC PROTECTION

A. Aluminum and Galvanized Steel:

1. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.
3. Allow coating to dry before installation of the material.
4. Protect coated surfaces during installation.
5. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.

B. Titanium: Where titanium equipment is in contact with concrete or dissimilar metal, provide full-face neoprene insulation gasket, 3/32-inch minimum thickness and 70-durometer hardness.

C. Stainless Steel:

1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.

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3. Remove contamination using cleaning and passivation methods in accordance with requirements of ASTM A380 and ASTM A967.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
5. After treatment, visually inspect surfaces for compliance.

3.06 PAINTING

A. Painted Galvanized Surfaces: Prepare as specified in Section 09 90 00, Painting and Coating.

B. Repair of Damaged Hot-Dip Galvanized Coating:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

C. Field Painting of Shop Primed Surfaces: Prepare surfaces and field finish in accordance with Section 09 90 00, Painting and Coating.

3.07 FIELD QUALITY CONTROL

A. Owner-Furnished Quality Assurance: In accordance with IBC Chapter 17 requirements.

B. Contractor-Furnished Quality Control: Certificate of Compliance per Section 01 43 33, Manufacturer’s Field Services, for test results, or calculations, or drawings that ensure material and equipment design and design criteria meet requirements of Section 01 61 00, Common Product Requirements.

3.08 MANUFACTURER’S SERVICES

A. Anchor Installation: Conduct site training of installation personnel for proper installation, handling, and storage of mechanical and adhesive anchor systems. Notify Engineer of time and place for sessions.

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3.09 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Hot-dip galvanized steel headed anchor bolts, unless indicated otherwise	
Exterior and Interior Wet Areas	Stainless steel headed anchor bolts	
Submerged and Corrosive Areas	Stainless steel headed anchor bolts	
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Interior Dry Areas	Stainless steel headed anchor bolts, unless otherwise specified with equipment	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel headed anchor bolts, unless otherwise specified with equipment	

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Service Use and Location	Product	Remarks
3. Drilled Anchors for Metal Components to Cast-in-Place Concrete (e.g., Ladders, Handrail Posts, Electrical Panels, and Equipment)		
Interior Dry Areas	Zinc-plated or stainless steel wedge or expansion anchors	Use zinc-plated undercut anchors for overhead and ceiling installations or Use zinc-plated wedge anchors approved for use in cracked concrete for overhead and ceiling installations.
Submerged, Exterior, Interior Wet, and Corrosive Areas	Adhesive stainless steel anchors	Use stainless steel undercut anchors for overhead and ceiling installations.
4. Connections for Structural Steel Framing		
Exterior and Interior Wet and Dry Areas	High-strength steel bolted connections	Use hot-dipped galvanized high-strength bolted connections for galvanized steel framing members.
5. Connections for Steel Fabrications		
Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections	
6. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
7. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

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B. Antiseizing Lubricant: Use on stainless steel threads.

C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

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SECTION 05 52 16
ALUMINUM RAILINGS

PART 1 GENERAL

1.01 REFERENCES

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

1. Aluminum Association, Incorporated (AA): DAF45, Designation System for Aluminum Finishes.
2. American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete.
3. American Iron and Steel Institute (AISI).
4. ASTM International (ASTM):
   a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   c. E894, Standard Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings.
   d. E935, Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.
   e. E985, Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.
5. International Code Council (ICC): International Building Code (IBC).
6. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: ICC report on evaluation of manufactured concrete anchor systems.

B. Railings: This term includes guardrail systems, handrail systems, platform railing systems, ramp-rail systems, and stair-rail systems. Railings may be comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.

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

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

1.03 DESIGN REQUIREMENTS

A. Structural Performance of Railing Systems: Design, test, fabricate, and install railings to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in railing system components.

1. Railing System: Capable of withstanding the following load cases applied:
   a. Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC and OSHA.
   b. Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
   c. Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
2. In-Fill Area of Railing Systems:
   a. Capable of withstanding a horizontally applied normal load of 50 pounds applied to 1 square foot at any point in system including panels, intermediate rails, balusters, and openings and space between railings.
   b. Horizontal concentrated load need not be assumed to act concurrently with loads on top rails of railings.
3. Calculated lateral deflection at top of posts shall not exceed 1 inch.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
   b. Manufacturer’s literature and catalog data of railing and components.
   c. Design Data: Calculations or test data using specified design performance loads and including the following:
      1) Bending stress in, and deflection of, posts in accordance with ASTM E985 as modified herein.
      2) Design of post base connection.

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3) Documentation that concrete anchors have been designed in accordance with one of the following:
   a) ACI 318, Chapter 17.
   b) ICC Evaluation Services Report for selected anchor.

2. Samples:
   a. Rail sections, 6 inches long showing each type of proposed connection, proposed finish, and workmanship.
   b. Each fitting including wall brackets, castings, toeboard, and rail expansion joints.

B. Informational Submittals:

1. Manufacturer's assembly and installation instructions.
2. Special Inspection: Manufacturer's instructions for Special Inspection of post-installed anchors.
3. Test Reports: Test data may supplement load calculations providing data covers complete railing system, including anchorage:
   a. Test data for railing and components showing load and deflection because of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
      1) Railing and post connections.
      2) Railing wall connections.
      3) Railing expansion joint connections.
      4) Railing system gate assembly, including latch, gate stop, and hinges. Both gate latch and stop to support required loads applied independent of each other.
      5) Railing picket panel clamps and connections.
   b. Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.
   c. Deflection Criteria: In accordance with ASTM E985 and design loads specified, except as follows: maximum calculated lateral deflection at top of posts shall not exceed 1 inch.
   d. Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.
4. Manufacturer's written recommendations describing procedures for maintaining railings including cleaning materials, application methods, and precautions to be taken in use of cleaning materials.

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1.05 QUALITY ASSURANCE

A. Qualifications: Calculations required for design data shall be stamped by a registered civil or structural engineer licensed in state where Project will be constructed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Package and wrap railings to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping to the extent possible until railing is completely installed.

B. Delivery:

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

1.07 ENVIRONMENTAL REQUIREMENTS

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

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

PART 2 PRODUCTS

2.01 ALUMINUM RAILINGS

A. General:

1. Furnish pre-engineered and prefabricated railing systems as shown on Drawings.
2. Railing systems using pop rivets or glued railing construction are not permitted.
3. Sand cast accessories and components are not permitted.
4. Fasteners shall be AISI Type 316 stainless steel, unless otherwise noted.

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B. Rails, Posts, and Formed Elbows:

1. Extruded Alloy 6105-T5, 6061-T6, “or-equal.”
2. Tensile Strength: 38,000 psi, minimum.
3. Yield Strength: 35,000 psi, minimum.
4. Wall Thickness: 0.145 inch, minimum.
5. Posts and railings shall be nominal 1-1/2-inch diameter pipe (1.90-inch outside diameter).

C. Accessories:

1. Fittings and Accessories:
   a. Extruded, machined bar stock, permanent mold castings, or die castings of sufficient strength to meet load requirements.
   b. Gauge metal components are not acceptable for load-resisting components.
   c. Fittings shall match color of pipe in railings.
2. Miscellaneous Extruded Aluminum Parts: Alloys 6063-T6, 6061-T6, or 6105-T5 aluminum, or equivalent, and of adequate strength for all loads.
3. Castings for Railings:
   a. Cast Al-mag with sufficient strength to meet load and test requirements.
   b. Anodizable grade finish with excellent resistance to corrosion when subjected to exposure of sodium chloride solution intermittent spray and immersion.
4. Post Anchorages:
   a. Refer to standard details for types of post anchorages and minimum requirements.
   b. Bolts at anchorages shall be minimum 1/2-inch diameter.
5. Wall Brackets: Adjustable wall fitting, with provision for minimum three 3/8-inch diameter AISI Type 316 stainless steel bolts or concrete anchors.
6. Rail Terminals (including Wall Returns): Aluminum wall fitting with provision for three 3/8-inch Type 304 fasteners.
7. Railing System Gate:
   a. Extruded aluminum rail components.
   b. Hardware Manufacturers and Products:
      1) Julius Blum & Co., Inc., Carlstadt, NJ; No. 782/3 gate hinges with springs, and No. 784 gate latch and stop.
      2) CraneVeyor Corp., South El Monte, CA; No. C4370b gate hinges with spring, No. C4369 gate latch, and No. C4368 gate stop.
      3) Moultrie Manufacturing Co., Moultrie, GA; Part No. W60006.

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8. Railing Picket Panels and Clamps:
   a. 1/2-inch Schedule 40 aluminum pipe (picket).
   b. Extruded aluminum 1-1/2-inch by 7/8-inch by 1/8-inch channel.
   c. Furnish neoprene plug for each end of picket.
   d. Fasteners: Stainless steel.
9. Toeboards:
   a. Molded or extruded Alloy 6063-T6 or 6061-T6 aluminum.
   b. Provide slotted holes for expansion and contraction where required.
10. Fasteners: Stainless steel.

D. Metal Supports Embedded in Concrete: In accordance with Section 05 50 00, Metal Fabrications.

E. Finishes:

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

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Locknuts, Washers, and Screws:

1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): AISI Type 316 stainless steel.
2. Flat Washers: Molded nylon.

B. Bolts and Nuts for Bolting Railing to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type 316 stainless steel.

C. Concrete Anchors:

1. Stainless steel, AISI Type 304 or Type 316.
2. Post-installed anchors in accordance with Section 05 50 00, Metal Fabrications, unless otherwise specified herein.
3. Bolt Diameter: 1/2-inch, minimum.

2.03 FABRICATION

A. Shop Assembly:

1. Post Spacing: Maximum 6-foot horizontal spacing.

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

B. Shop/Factory Finishing:

1. Use same alloy for uniform appearance throughout fabrication for railings.
2. Railing and Post Fittings: Match fittings with color of pipe in railing.

C. Shop Assembly:

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

D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

A. Field fabrication of aluminum railing systems is not permitted.

B. Where required, provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on actual structure.

C. Install railing with base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in field and exceeds plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest set-screw or bolt in base fitting.

D. Modification to supporting structure is not permitted where railing is to be attached.

E. Protection from Entrapped Water:

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

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3.02 RAILING INSTALLATION

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

B. Expansion Joints:

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

C. Posts and Rails:

1. Surface Mounted Posts:
   a. Bolt post baseplate connectors firmly in place.
   b. Shims, wedges, grout, and similar devices for railing post alignment not permitted.
2. Install posts and rails in same plane.
3. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
4. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
5. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

D. Wall Brackets: Support wall rails on brackets spaced maximum 5 feet on centers as measured on the horizontal projection.

E. Toeboard:

1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or at stairways unless shown otherwise.
2. Accurately measure in field for correct length; after railing post installation cut and secure to posts.
3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
4. Install plumb and aligned to within 1/8 inch in 12 feet.

F. Railing System Gate: Install in accordance with manufacturer's installation instructions.

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3.03 FIELD FINISHING

A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY CONTROL

A. Post-installed anchors supporting railing systems require special inspection.

B. Owner-Furnished Quality Assurance, in accordance with ICC IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

3.05 CLEANING

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

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

C. If stain remains after washing, restore in accordance with railing manufacturer’s recommendations or replace stained railings.

END OF SECTION

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SECTION 05 53 00
METAL GRATINGS

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 SUBMITTALS

A. Action Submittals:

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

B. Informational Submittals:

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

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1.03 DELIVERY, STORAGE, AND HANDLING

A. Insofar as is practical, factory assemble items.

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. IKG Industries, Houston, TX.
3. Ohio Gratings, Inc., Canton, OH.

2.02 GRATING MATERIALS

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

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

2.03 METAL BAR GRATING

A. General Requirements:

1. Maximum Service Load:
   a. Light Duty (Type A): 100 psf uniformly distributed load.
   b. Medium Duty (Type B): 500 psf uniformly distributed load.
2. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
3. Bearing Bar Spacing:
   a. Light Duty: 1-3/16 inch maximum, center-to-center.
   b. Medium Duty: 15/16 inch.
4. Cross Bar Spacing: 4 inches maximum, center-to-center.
5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 531 or as shown on Drawings.

B. Grating Materials: Aluminum, pressure-locked rectangular bar grating fabricated by pressing crossbars between rectangular bearing bars.

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C. Surface: Slip resistant, consisting of an applied abrasive finish of aluminum-oxide aggregate.

2.04 ACCESSORIES

A. Embedded Frames: As indicated on Drawings and as specified in Section 05 50 00, Metal Fabrications.

B. Grating Clamps:

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

C. Anchor Stud and Saddle Clip:

1. Use at embedded angle frame supports with stud anchor and nut recessed below top of grating surface.
2. Removable from above grating walkway surface.
3. Provide Type 316 stainless steel welded threaded stud anchor, nut, washer, and saddle clip.
4. Manufacturers and Products:
   a. Welded Stud Anchor:
      1) Nelson Stud Welding, Inc., Elyria, OH.
      2) Stud Welding Associates, Inc. Elyria, OH.
   b. Saddle Clip:
      1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
      2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
      3) Struct-Fast, Inc., Baltimore, MD; Gratefast.

2.05 FABRICATION

A. General:

1. In accordance with NAAMM MBG 531 or NAAMM MBG 532.
2. Do not weld aluminum grating.
3. Conceal fastenings where practical.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.

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

B. Metal Bar Grating: A single grating section shall be not less than 1.5 feet or greater than 4 feet in width, or weigh more than 150 pounds.

C. Heavy Duty Metal Bar Grating: Minimum width of grating sections shall be 2 feet regardless of length and weight.

D. Supports:

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

PART 3 EXECUTION

3.01 PREPARATION

A. Electrolytic Protection:

1. Protect aluminum surfaces in contact with dissimilar metals, or embedded or in contact with masonry, grout, or concrete as specified in Section 09 90 00, Painting and Coating.
2. Allow paint to dry before installation of material.

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3.02 INSTALLATION

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

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

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

D. Install grating supports plumb and level as applicable.

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

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

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

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

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

J. Protect painted and galvanized surfaces during installation.

K. Repair damaged coatings as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

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SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

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

1. American Water Works Association (AWWA):
   a. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.
   b. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   c. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   d. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
2. Environmental Protection Agency (EPA).
3. International Concrete Repair Institute: Technical Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
4. NACE International (NACE): SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
5. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
6. Occupational Safety and Health Act (OSHA).
7. The Society for Protective Coatings (SSPC):
   a. PA 2, Measurement of Dry Coating Thickness with Magnetic Gages.
   b. PA 3, Guide to Safety in Paint Applications.
   c. SP 1, Solvent Cleaning.
   d. SP 2, Hand Tool Cleaning.
   e. SP 3, Power Tool Cleaning.
   f. SP 5, White Metal Blast Cleaning.
   g. SP 6, Commercial Blast Cleaning.
   h. SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
   i. SP 10, Near-White Blast Cleaning.
   j. SP 11, Power Tool Cleaning to Bare Metal.
   k. SP 12, Surface Preparation and Cleaning of Metals Waterjetting Prior to Recoating.
   l. SP 13, Surface Preparation of Concrete.

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m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.

1.02 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
2. FRP: Fiberglass Reinforced Plastic.
3. HCl: Hydrochloric Acid.
4. MDFT: Minimum Dry Film Thickness, mils.
5. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
6. Mil: Thousandth of an inch.
7. PPDS: Paint Product Data Sheet.
8. PSDS: Paint System Data Sheet.
9. PVC: Polyvinyl Chloride.
10. SFPG: Square Feet per Gallon.
11. SFPGPC: Square Feet per Gallon per Coat.
12. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Data Sheets:
      1) For each product, furnish a Paint Product Data Sheet (PPDS), the manufacturer’s technical data sheets, and paint colors available (where applicable). The PPDS form is appended to the end of this section.
      2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
      3) Technical and performance information that demonstrates compliance with Specification.
      4) Furnish copies of paint system submittals to the coating applicator.
      5) Indiscriminate submittal of only manufacturer’s literature is not acceptable.
   b. Detailed chemical and gradation analysis for each proposed abrasive material.

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2. Samples:
   a. Proposed Abrasive Materials: Minimum 5-pound sample for each type.
   b. Reference Panel:
      1) Surface Preparation:
         a) Prior to start of surface preparation, furnish a 4-inch by 4-inch 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) Panel to be reference source for inspection upon approval by Engineer.
      2) Paint:
         a) Unless otherwise specified, before painting work is started, prepare minimum 8-inch by 10-inch sample with type of paint and application specified on similar substrate to which paint is to be applied.
         b) Furnish additional samples as required until colors, finishes, and textures are approved.
         c) Approved samples to be the quality standard for final finishes.

B. Informational Submittals:

1. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
2. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
3. Manufacturer's written verification that submitted material is suitable for the intended use.
4. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
5. Manufacturer's written instructions and special details for applying each type of paint.

1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

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B. Regulatory Requirements:

1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
2. Perform surface preparation and painting in accordance with recommendations of the following:
   a. Paint manufacturer's instructions.
   b. SSPC PA 3, Guide to Safety in Paint Applications.
   c. Federal, state, and local agencies having jurisdiction.

C. Mockup:

1. Before proceeding with Work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
2. After Engineer approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.
2. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

B. Minimum of 5 years' verifiable experience in manufacture of specified product.

C. Each of the following manufacturers is capable of supplying most of the products specified herein:

1. Sherwin-Williams.
2. TENEMEC.
3. Carboline.

2.02 ABRASIVE MATERIALS

A. Select abrasive type and size to produce surface profile that meets coating manufacturer's recommendations for specific primer and coating system to be applied.

2.03 PAINT MATERIALS

A. General:

1. Manufacturer's highest quality products suitable for intended service.
2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

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B. Products:

Product	Definition
Acrylic Latex	Single-component, finish as required
Alkyd Enamel	Optimum quality, gloss or semigloss finish as required, medium long oil
Bituminous Paint	Single-component, coal-tar pitch based
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments
Epoxy Primer—Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
NSF Epoxy	Polyamidoamine epoxy, approved for potable water contact and conforming to NSF 61
Epoxy, 100% Solids	100% volume solids, amine-cured epoxy, suitable for immersion service in a potable water clarifier, approved for potable water contact and conforming to NSF 61
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish
Resurfacing Mortar	Epoxy modified cementitious resurfacing mortar
Rust-Inhibitive Primer	Single-package steel primers with anticorrosive pigment loading
Surface Tolerant Epoxy	Epoxy mastic suitable for application over marginally prepared surfaces

2.04 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.

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3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting and for painting other small areas.
5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

2.05 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment Specifications, such equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation.
2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, tie-coat shall be surface tolerant epoxy as recommended by manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:
   a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
   b. The surface preparation and application of the primer shall be performed by pipe manufacturer.
   c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
   d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.

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PART 3 EXECUTION

3.01 GENERAL

A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.

B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.

C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

A. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.

B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

D. Mask openings in motors to prevent paint and other materials from entering.

E. Protect surfaces adjacent to or downwind of Work area from overspray.

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3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.
3. Where the specified degree of surface preparation differs from manufacturer's recommendations, the more stringent shall apply.

B. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
   a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
   b. SP 2, Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using nonpower hand tools.
   c. SP 3, Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using power-assisted hand tools.
   d. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.
   e. SP 6, Commercial Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 33 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
   f. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.
   g. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations

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caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

h. SP 11, Power Tool Cleaning to Bare Metal: Removal of visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter using power-assisted hand tools capable of producing suitable surface profile. Slight residues of rust and paint may be left in lower portion of pits if original surface is pitted.

i. SP 12, Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating: Surface preparation using high-pressure and ultrahigh-pressure water jetting to achieve specified surface cleanliness condition. Surface cleanliness conditions are defined in SSPC SP 12 and are designated WJ-1 through WJ-4 for visual surface preparation definitions and SC-1 through SC-3 for nonvisual surface preparation definitions.

2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
5. Hand tool clean areas that cannot be cleaned by power tool cleaning.
6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
7. Welds and Adjacent Areas:
   a. Prepare such that there is:
      1) No undercutting or reverse ridges on weld bead.
      2) No weld spatter on or adjacent to weld or any area to be painted.
      3) No sharp peaks or ridges along weld bead.
   b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
8. Preblast Cleaning Requirements:
   a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
   b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.

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c. Clean small isolated areas as above or solvent clean with suitable solvent and clean cloth.

9. Blast Cleaning Requirements:
   a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer's recommendations.
   b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
   c. Use only dry blast cleaning methods.
   d. Do not reuse abrasive, except for designed recyclable systems.
   e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.
10. Post-Blast Cleaning and Other Cleaning Requirements:
   a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
   b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.

C. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:

1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.
2. Remove oil and grease by wiping or scrubbing surface with suitable solvent, rag, and brush. Use clean solvent and clean rag for final wiping to avoid contaminating surface.
3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.

D. Concrete Surface Preparation:

1. Do not begin until 30 days after concrete has been placed.
2. Meet requirements of SSPC SP 13.
3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding.

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5. Repair bug holes and other surface imperfections per coating manufacturers recommendations for architectural concrete coatings.
6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

E. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.
2. Large areas may be power sanded or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

F. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.
2. Clean loose, abraded, or damaged coatings to substrate by hand or power tool, SP 2 or SP 3.
3. Feather surrounding intact coating.
4. Apply one spot coat of specified primer to bare areas, overlapping prepared existing coating.
5. Apply one full finish coat of specified primer to entire surface.
6. If an aged, plural-component material is to be topcoated, contact coating manufacturer for additional surface preparation requirements.
7. For ductile iron pipe with asphaltic varnish finish not specified to be abrasive blasted, apply coat of tar stop prior to application of cosmetic finish coat.
8. Application of Cosmetic Coat:
   a. It is assumed that existing coatings have oxidized sufficiently to prevent lifting or peeling when overcoated with paints specified.
   b. Check compatibility by application to a small area prior to starting painting.
   c. If lifting or other problems occur, request disposition from Engineer.
9. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.

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3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Acid Etching:

1. After precleaning, spread the following solution by brush or plastic sprinkling can:
   a. One-part commercial muriatic acid reduced by two parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.
2. Application:
   a. Rate: Approximately 2 gallons per 100 square feet.
   b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.
   c. Acid will react vigorously for a few minutes, during which time brushing shall be continued.
   d. After bubbling subsides (10 minutes), hose down remaining slurry with high pressure clean water.
   e. Rinse immediately to avoid formation on the surface of salts that are difficult to remove.
   f. Thoroughly rinse to remove any residual acid surface condition that may impair adhesion.
3. Ensure surface is completely dry before application of coating.
4. Apply acid etching to obtain a “grit sandpaper” surface profile. If not, repeat treatment.

C. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

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3.06 APPLICATION

A. General:

1. The intention of these Specifications is for new, interior and exterior metal, and submerged metal surfaces to be painted, whether specifically mentioned or not, except as specified otherwise. Concrete surfaces to be coated where indicated.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals, unless otherwise specified.
3. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer's written instructions for these requirements. Do not immerse coating until completion of curing cycle.
4. Apply coatings in accordance with these Specifications and paint manufacturers' printed recommendations and special details. The more stringent requirements shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
5. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
6. Fusion Bonded Coatings Method Application: Electrostatic, fluidized bed, or flocking.
7. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.
8. On pipelines, terminate coatings along pipe runs to 1 inch inside pipe penetrations.
9. Keep paint materials sealed when not in use.
10. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Prepare surface and apply primer in accordance with System No. 10 Specification.
3. Apply intermediate and finish coats of the coating system appropriate for the exposure.

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C. Porous Surfaces, Such as Concrete and Masonry:

1. Filler/Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.
2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
   a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
   a. Minimum required without regard to coating thickness.
   b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
   a. Do not exceed coating manufacturer's recommendations.
   b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
   a. Perform with properly calibrated instruments.
   b. Recoat and repair as necessary for compliance with Specification.
   c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

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B. System No. 1 Submerged Metal—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	NSF Epoxy	3 coats, 3 MDFTPC

1. Use on the following items or areas:
   a. Metal surfaces new and below a plane 1 foot above the maximum liquid surface; metal surfaces above the maximum liquid surface that are a part of the immersed equipment; surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel that are submerged and embedded in concrete; and the following specific surfaces:
      1) Metal surfaces located inside the clarifier.

C. System No. 2 Submerged Metal—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	Prime in accordance with manufacturer's recommendations	
	High Build Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
   a. The following specific surfaces:
      1) Exterior of steel or ductile iron piping submerged or embedded in concrete.
      2) Buried ferrous metal or stainless steel piping and appurtenances.
   b. New metal surfaces below a plane 1 foot above maximum liquid surface, metal surfaces above maximum liquid surface that are a part of immersed equipment, concrete embedded surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel.

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D. System No. 2A Exposed Rebar and Exposed Anchor Bolts:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 2 Hand Tool Cleaning/SP 3, Power Tool Cleaning	Prime in accordance with manufacturer's recommendations	
	Surface Tolerant Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
   a. Rebar and anchor bolts exposed during demolition/cutting activities. Exposed rebar located in concrete that will receive a concrete lining does not require this coating.

E. System No. 4 Exposed Metal—Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	High Build Epoxy	1 coat, 4 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and existing located inside or outside of structures and exposed to weather, and the following specific surfaces:
      1) Sludge piping located inside Sludge Pump Station No. 2.

F. System No. 5 Exposed Metal—Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, located inside or outside of structures and exposed to weather or in a highly humid atmosphere, such as pipe galleries and similar areas, and the following specific surfaces:
      1) As noted in the Architectural Schedules on Drawings.

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G. System No. 6 Exposed Metal—Atmospheric:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Rust-Inhibitive Primer	1 coat, 2 MDFT
	Alkyd Enamel	2 coats, 4 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and located inside or outside of structures or exposed to weather, including the following specific surfaces:
      1) Mechanical equipment.
      2) Handrail.
      3) Miscellaneous exposed metal surfaces.
   b. Apply surface preparation and primer to surfaces prior to installation. Finish coats need only be applied to surfaces exposed after completion of construction.

H. System No. 7 Concrete Encased Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Coal-Tar Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
   a. Use on nonsubmerged concrete encased ferrous metals including wall pipes, pipe sleeves, access manholes, gate guides, and thimbles.

I. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Epoxy Primer - Other	As recommended by coating manufacturer Remaining coats as required for exposure

1. Use on the following items or areas:
   a. Galvanized surfaces requiring painting.
   b. After application of System No. 10, apply finish coats as required for exposure.

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J. System No. 18 Concrete Tank Lining—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation Achieve manufacturer's recommended Concrete Surface Profile in accordance with ICRI 310.2R	Resurfacing Mortar	Number of coats and thickness shall be as required to resurface, smooth, and level 100 percent of existing concrete surfaces to be coated. Expected Total Thickness: 1/4-inch to 1/2-inch
	Primer Coat (to reduce outgassing/pinholing): NSF Epoxy	1 coat, 4-6 MDFT
	Epoxy, 100% Solids	1 coat, 25 MDFT

1. Use on the following items or areas:
   a. Concrete surfaces below the top of walls, including walls, floor, ceilings and miscellaneous concrete structures, and the following specific structures:
      1) Inside of the rapid mix and the inlet channel and flocculation area of clarifier.
   b. Where rebar is exposed during concrete surface preparation operations, prepare exposed metal surfaces in accordance with SSPC-SP10 and apply one coat of Epoxy, 100 percent solids at 20 MDFT.

K. System No. 25 Exposed FRP, PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex Semigloss	2 coats, 320 SFPGPC

1. Use on the following items or areas:
   a. All exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat.
   b. Color coding on PVC pipe.

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L. System No. 27 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1)	Prime in accordance with manufacturer's recommendations	
	Bituminous Paint	1 coat, 10 MDFT

1. Use on aluminum surfaces embedded or in contact with concrete.

M. System No. 112 Concrete:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Cement Based Waterproofing base coat	1 coat "Tamoseal with AKKRO-7T"; "or-equal"
	Non-cementitious high build 100 % Acrylic Resin Polymer top coat	1 coat "Tammscoat Smooth" "or-equal," 80 SFPGPC

1. Use on the following items or areas:
   a. Exterior exposed concrete surfaces to 1-foot below grade on the Clarifier, Raw Water Meter Vault, Rapid Mix, and Sludge Pump Station No. 2, as indicated on Drawings.

3.08 COLORS

A. Provide as selected by Owner or Engineer.

B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.

C. Equipment Colors:

1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint equipment and piping one color as selected.
3. Paint nonsubmerged portions of equipment the same color as the piping it serves, except as itemized below:
   a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
   b. Fire Protection Equipment and Apparatus: OSHA Red.
   c. Radiation Hazards: OSHA Purple.
   d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

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D. Pipe Identification Painting:

1. Color code nonsubmerged metal piping, except electrical conduit. Paint fittings and valves the same color as pipe, except equipment isolation valves.
2. Pipe Color Coding: As shown in table below.
3. On exposed stainless steel piping, apply color 24 inches in length along pipe axis at connections to equipment, valves, or branch fittings, at wall boundaries, and at intervals along piping not greater than 9 feet on center.
4. Pipe Supports: Painted light gray, as approved by Owner.
5. Fiberglass reinforced plastic (FRP) pipe located inside of buildings and enclosed structures will not require painting, except as noted or scheduled.

E. Pipe System Color Code:

Pipe System	Color
Drains and Sludge	Light Brown
Raw Water	Buff
Plant Service Water	Medium Blue
Sample	Medium Green

3.09 FIELD QUALITY CONTROL

A. Testing Equipment:

1. Provide magnetic or ultrasonic type dry film thickness gauge, as required for substrate, to test coating thickness specified in mils, as manufactured by DeFelsko Corp., Ogdensburg, NY, PosiTector; “or-equal.”
2. Provide low-voltage wet sponge electrical holiday detector to test completed coating systems, 20 mils dry film thickness or less, except zinc primer, high-build elastomeric coatings, and galvanizing, for pinholes, holidays, and discontinuities, as manufactured by Tinker and Rasor, San Gabriel, CA, Model M-1.
3. Provide high-voltage spark tester to test completed coating systems in excess of 20 mils dry film thickness. Unit as recommended by coating manufacturer.

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B. Testing:

1. Thickness Testing:
   a. Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
   b. Concrete (System No. 18): Measure coating thickness specified in mils with ultrasonic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement until coating is sufficiently cured per the manufacturer's directions.
2. Continuity Testing:
   a. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
   b. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE SP0188.
3. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

C. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.

D. Unsatisfactory Application:

1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
3. Repair defects in accordance with written recommendations of coating manufacturer.

E. Damaged Coatings, Pinholes, and Holidays:

1. Feather edges and repair in accordance with recommendations of paint manufacturer.
2. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather the edges. Follow with primer and finish coat. Depending on

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extent of repair and appearance, a finish sanding and topcoat may be required.

3. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.10 MANUFACTURER'S SERVICES

A. In accordance with Section 01 43 33, Manufacturers' Field Services, coating manufacturer's representative shall be present at Site as follows:

1. On first day of application of any coating system.
2. A minimum of one additional Site inspection visit, for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
3. As required to resolve field problems attributable to or associated with manufacturer's product.
4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.11 CLEANUP

A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.

B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.12 SUPPLEMENTS

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

1. Paint System Data Sheet (PSDS).
2. Paint Product Data Sheet (PPDS).

END OF SECTION

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PAINT SYSTEM DATA SHEET (PSDS)

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Number (from Spec.):		
Paint System Title (from Spec.):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	**Product Name/Number (Proprietary)**	**Min. Coats, Coverage**

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PAINT PRODUCT DATA SHEET (PPDS)

Complete and attach manufacturer's Technical Data Sheet to this PPDS for each product submitted. Provide manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer's recommendations for the following:

Mixing Ratio: _____

Maximum Permissible Thinning:_____

Ambient Temperature Limitations: min.:_____ max.:_____

Surface Temperature Limitations: min.:_____ max.:_____

Surface Profile Requirements: min.:_____ max.:_____

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SECTION 22 10 01
PLUMBING PIPING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

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

1. American National Standards Institute (ANSI).
2. American Public Works Association (APWA): Uniform Color Code.
3. American Water Works Association (AWWA):
   a. C104/A21.4, Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.
   c. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   d. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   e. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast.
   f. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines, Enamel and Tape, Hot-Applied.
   g. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
   h. C606, Grooved and Shouldered Joints.
   i. C651, Disinfecting Water Mains.
4. ASTM International (ASTM): A536, Standard Specification for Ductile Iron Castings.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Local plumbing code with local amendments (based on 2015 Uniform Plumbing Code).

1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets.

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2. Shop Drawings:
   a. Show Contractor recommended changes in location of fixtures or equipment.
   b. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. Isometric riser diagrams.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Changes in location of equipment or piping that affect connecting or adjacent work, before proceeding with the work.
3. Complete list of products proposed for installation.
4. Test records produced during testing.
5. For Polyethylene (PE) Pipe:
   a. Certificates of qualification for persons to be fusing PE pipe.
   b. Experience and training record of persons to be fusing PE pipe.
   c. Testing Plan:
      1) Submit at least 15 days prior to testing; include following as a minimum:
         a) Testing dates.
         b) Piping systems and section(s) to be tested.
         c) Method of isolation.
         d) Method of conveying water from source to system being tested.
   d. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
   e. Test report documentation.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the

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maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

A. Piping Schedule: Refer to Section 40 27 00, Process Piping—General.

B. Piping Material: Refer to Piping Data Sheet(s), Article Supplements and Section 40 27 00, Process Piping—General.

2.03 HOSE VALVES AND HYDRANTS

A. YH-2, Post Hydrant:

1. Ductile iron casing, 4-inch inlet and 4-inch NPT outlet, for 3-foot of bury.
2. Principal interior parts shall be removable for service without excavation.
3. Equip with restrained mechanical joint for connection to firewater system.
4. Manufacturer and Product:
   a. Kupferle Foundry Company; Mainguard #7500.
   b. “Or-equal.”

B. HV-5, Hose Valve:

1. Cast bronze globe valve, 1-1/2-inch size, with NPT screwed ends, union bonnet, rising stem, Teflon disc, hand wheel, and NPT x NST hose thread adapter outlet connection.
2. Rated 150-pound SWP, 300-WOG.
3. Manufacturers and Products:
   a. Nibco; Catalog No. T-235-Y, Angle No. T-335-Y.
   b. Crane Co.; Catalog No. 7TF, Angle No. 17TF.

C. WM-1, Water Monitor:

1. Configuration 1: Coated carbon steel, epoxy finish mountable monitor, 2.5-inch base female stainless steel NPT inlet, 2.5-inch male NH outlet. To be mounted using cam and groove fittings.
2. Configuration 2: Coated carbon steel, epoxy finish, 2.5-inch MPT inlet, 2.5-inch flanged ANSI B16.5 outlet.
3. Flow Rate: 200 gpm to 1,000 gpm.

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4. Travel: Vertical plus 75 degrees, minus 90 degrees, horizontal 360 degrees rotation.
5. Manufacturer and Product:
   a. Stang; 925 Snorkel Monitor.
   b. “Or-equal.”

2.04 PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems.

2.05 INSULATION

A. As specified in Section 40 42 13, Process Piping Insulation.

2.06 VALVES

A. Refer to Section 40 27 02, Process Valves and Operators.

PART 3 EXECUTION

3.01 GENERAL

A. Refer to the Area Classification Table in the General Section of Drawings for installation material requirements.

B. Install plumbing systems to meet applicable plumbing code.

C. Field Obstructions:

1. Drawings do not attempt to show exact details of piping. Provide offsets around obstructions.
2. Do not modify structural components, unless approved by Engineer.

D. Sleeves:

1. Pipe sizes shown are nominal sizes, unless shown or specified otherwise.
2. Provide piping passing through walls, floors, or ceilings with standard-weight pipe sleeves.
3. Provide pipes passing through finished walls with chrome-plated canopy flanges.
4. Dry pack sleeves in existing work in-place and provide finished appearance.
5. Pack holes left by removal of existing piping with grout and finish to match adjacent surface.

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E. Provide unions in piping systems at connections to equipment.

F. Provide shielded transition couplings, insulating dielectric unions and flanges between ferrous and nonferrous piping and where otherwise required for electrically insulated connection.

G. Provide isolation valves and strainers at pressure regulators.

H. Trench Excavation and Backfill: As specified in Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

3.02 INSTALLATION

A. Steel Pipe:

1. Ream, clean, and remove burrs and mill scale from piping before making up.
2. Seal joints with pipe joint sealer or Teflon tape.

B. Valves: Install in accordance with manufacturer's recommendations.

C. Miscellaneous Piping Specialties: Install in accordance with manufacturer's recommendations.

3.03 WATER SUPPLY PIPING

A. Flush water piping systems clean of internal debris, clean faucet aerators, and adjust plumbing fixture valves for manufacturer's recommended flow.

B. Do not run water piping through electrical rooms, stairwells, server rooms, telephone closets, or immediately over or within a 3-foot horizontal clearance of electrical panels, motor starters, local control panels, network switch panels, network patch panels, or environmental control panels.

C. Provide exterior water piping with minimum 3 feet of cover or install below frost line, whichever is greater.

D. Hose Valves and Hydrants: Attach handle with setscrew and provide manufacturer's recommended gravel fill around drain hole of post hydrants.

E. Provide valve operators with position indicators, where indicated, to show position of valve disc or plug.

3.04 INSULATION

A. As specified in Section 40 42 13, Process Piping Insulation.

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3.05 HANGERS AND SUPPORTS

A. In accordance with Section 40 05 15, Piping Support Systems.

3.06 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.07 INTERIM CLEANING

A. As specified in Section 40 27 00, Process Piping—General.

3.08 TESTING

A. As specified in Section 40 80 01, Process Piping Leakage Testing.

3.09 CORROSION PROTECTION

A. As specified in Section 40 27 00, Process Piping—General.

3.10 FIELD FINISHING

A. In accordance with Section 40 27 00, Process Piping—General.

3.11 PIPING IDENTIFICATION

A. Refer to Section 40 27 00, Process Piping—General, and Piping Schedule.

END OF SECTION

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SECTION 26 05 01
ELECTRICAL

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway Transportation Officials (AASHTO).
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A240/A240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
   c. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
   d. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
3. Electronic Industries Association (EIA/TIA): 569, Commercial Building Standard for Telecommunications Pathways and Spaces.
4. Federal Specifications (FS):
   a. W-C-596, Connector, Electrical, Power, General Specification for.
   b. W-S-896, Switch, Toggle (Toggle and Lock), Flush Mounted (General Specification).
5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   b. PC62.41.1, Draft Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
   c. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   d. 114, Standard Test Procedures for Single-Phase Induction Motors.
6. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
7. Illuminating Engineering Society of North America (IESNA): HB-9, Lighting Handbook.

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8. National Electrical Contractor's Association, Inc. (NECA): 1, Standard Practices for Good Workmanship in Electrical Contracting.
9. National Electrical Manufacturers Association (NEMA):
    a. C80.1, Rigid Steel Conduit-Zinc Coated.
    b. C80.3, Electrical Metallic Tubing-Zinc Coated.
    c. C80.6, Intermediate Metal Conduit-Zinc Coated (IMC).
    d. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
    e. CC1, Electrical Power Connectors for Substations.
    f. ICS 1, Industrial Control and Systems: General Requirements.
    g. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC.
    h. ICS 2.3, Industrial Control and Systems: Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers.
    i. MG 1, Motors and Generators.
    j. PB 1, Panelboards.
    k. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
    l. ST 20, Dry Type Transformers for General Applications.
    m. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
    n. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
    o. WC 55, Instrumentation Cables and Thermocouple Wire.
    p. WC 70, Standard for Non-Shielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy.
    q. WC 71, Standard for Non-Shielded Cables Rated 2001-5000 Volts for use in the Distribution of Electrical Energy.
    r. WC 74, 5-46 KV Shielded Power Cable for use in the Transmission and Distribution of Electric Energy.
    s. WD 1, General Color Requirements for Wiring Devices.
10. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
11. UL:
    a. 1, Flexible Metal Conduit.
    b. 6, Electrical Rigid Metal Conduit—Steel.
    c. 13, Power-Limited Circuit Cables.
    d. 44, Thermoset Insulated Wires and Cables.
    e. 62, Flexible Cord and Fixture Wire.
    f. 67, Panelboards.
    g. 98, Enclosed and Dead-Front Switches.

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h. 198C, High Interrupting Capacity Fuses, Current Limiting Types.
i. 198E, Class R Fuses.
j. 360, Liquid-Tight Flexible Steel Conduit.
k. 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors.
l. 486C, Splicing Wire Connectors.
m. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
n. 508, Industrial Control Equipment.
o. 510, Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
p. 514B, Fittings for Cable and Conduit.
q. 651, Schedule 40 and 80 PVC Conduit.
r. 674, Electric Motors And Generators for use in Division 1 Hazardous (Classified) Locations.
s. 797, Electrical Metallic Tubing.
t. 854, Service-Entrance Cables.
u. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
v. 943, Ground-Fault Circuit Interrupters.
w. 1059, Terminal Blocks.
x. 1242, Intermediate Metal Conduit.
y. 1277, Electrical Power and Control Tray Cables with Optional Optical-Fibre Members.
z. 1449, Transient Voltage Surge Suppressors.
aa. 1561, Dry-Type General Purpose and Power Transformers.
bb. 2111, Overheating Protection for Motors.

1.02 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. MCOV: Maximum Allowable Continuous Operating Voltage.

C. MOV: Metal Oxide Varistor.

D. SASD: Silicon Avalanche Suppressor Diode.

E. SVR: Surge Voltage Rating.

F. SPD: Surge Protective Device.

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1.03 SUBMITTALS

A. Action Submittals:

1. Boxes and device plates.
2. Junction and pullboxes.
3. Precast handholes.
4. Wiring devices.
5. Panelboards and mini-power centers.
6. Circuit breakers and switches.
7. Motor-rated switches.
8. Control devices, terminal blocks, and relays.
9. Contactors.
10. Transformers.
11. Support and framing channels.
12. Nameplates and nameplate schedule.
13. Conduit, fittings, and accessories.
14. Conductors, cables, and accessories.
15. Grounding materials.
16. Luminaires.
17. Motors.
18. Motor Controls: Arrangement drawings, ratings, schematic and wiring diagrams, bill of materials, nameplate schedule, manufacturer information on components.
19. Local Control Panels: Arrangement drawings, schematic and wiring diagrams, bill of materials, nameplate schedule, manufacturer information on components.

1.04 APPROVAL BY AUTHORITY HAVING JURISDICTION

A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark or label.

1.05 QUALIFICATIONS

A. PVC-Coated, Rigid Aluminum Conduit Installer: Must be certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

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PART 2 PRODUCTS

2.01 GENERAL

A. Products shall comply with all applicable provisions of NFPA 70.

B. Like Items of Equipment: End products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

C. Equipment and Devices Installed Outdoors or in Unheated Enclosures: Capable of continuous operation within ambient temperature range of 0 degrees F to 120 degrees F.

D. Equipment Finish: Manufacturer's standard finish color, except where specific color is indicated.

2.02 OUTLET AND DEVICE BOXES

A. Cast Aluminum:

1. Box: Cast, copper-free aluminum.
2. Cover: Gasketed, weatherproof, copper-free aluminum with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.
5. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS-SA or FD-SA.
   b. Appleton; Type FS or FD.

2.03 JUNCTION AND PULL BOXES

A. Outlet Boxes Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Cast Aluminum Box:

1. NEMA 250, Type 4.
2. Box: Cast copper-free aluminum, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Nonhinged with neoprene gasket.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
   a. Crouse-Hinds; Series N-SA.
   b. O-Z/Gedney; Series YS-A, YL-A.

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C. Stainless Steel Box:

1. NEMA 250, Type 4X.
2. Box: 14-gauge, ASTM A240, Type 316 stainless steel, with white enamel painted interior mounting panel.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel quick release luggage type latches.
5. Provide integral conduit hubs (or use Meyer type hubs) for termination of conduit.
6. Manufacturers:
   a. Hoffman Engineering Co.
   b. Robroy Industries.

2.04 PRECAST HANDHOLES

A. Concrete Strength: Minimum 3,000 psi compressive, in 28 days.

B. Loading: AASHTO H-10 or H-20, as noted below, in accordance with ASTM C857.

C. Drainage:

1. Slope floors toward drain points leaving no pockets or other nondraining areas.
2. Provide drainage outlet at low point of floor.

D. Raceway Entrances: Provide knockout panels, or precast individual raceway openings on all four sides.

E. Handhole Frames and Covers:

1. Material: Steel, hot-dipped galvanized.
2. Cover Type: Solid, bolt-on or hinged, of checkered design, as noted below.
3. Cover Loading: As noted below.
4. Cover Designation: Lettering minimum 2 inches in height, as shown.

F. Hardware: Steel, hot-dip galvanized.

G. Furnish knockout for ground rod in each handhole.

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H. Manufacturer and Models: Utility Vault Company.

1. Small: H-10 incidental traffic loading; Model 3030-B with 3030-DP cover.
2. Large: H-20 off-street traffic loading; Model 444-LA with 44-332P cover.

2.05 WIRING DEVICES

A. Switches:

1. NEMA WD 1 and FS W-S-896.
2. Industrial grade, totally enclosed, ac type, with quiet tumbler switches and screw terminals.
3. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
4. Rating: 20 amps, 120/277 volts.
5. Color: Brown.
6. Automatic grounding clip and integral grounding terminal on mounting strap.
7. Manufacturers and Products:
   a. Leviton; 1201/1221 Series.
   b. Bryant; 4801/4901 Series.
   c. Hubbell; 1202/1222 Series.

B. Receptacle, Single and Duplex:

1. NEMA WD 1 and FS W-C-596.
2. Specification grade duplex, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
3. High strength, thermoplastic base color.
4. Color: Brown.
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
7. One-piece mounting strap with integral ground contact (rivetless construction).
8. Manufacturers and Products:
   a. Leviton; 5262/5362 Series.
   b. Bryant; 5262/5362 Series.
   c. Hubbell; 5262/5362 Series.

C. Receptacle, Ground Fault Circuit Interrupter:

1. Duplex, listed Class A to UL Standard 943, tripping at 5 mA.

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2. Color: Brown.
3. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
4. Size: For 2-inch by 4-inch outlet boxes.
5. Standard Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
6. Impact resistant nylon face.
7. Manufacturers:
   a. Bryant.
   b. Hubbell.
   c. Leviton.

2.06 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Cast Metal:

1. Material: Copper-free aluminum with gaskets.
2. Screw: Oval-head stainless steel.

C. Engraved:

1. Character Height: 1/8 inch.
2. Filler: White background, black letters.

D. Weatherproof:

1. Receptacles, for Indoor Damp Locations:
   a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
   b. Mounting Screw and Cap Spring: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; Type WLRD-1.
      2) Appleton; Type FSK-WRD.
2. Receptacles, Outdoor Locations:
   a. UL listed for wet location while in use.
   b. Gasketed, cast aluminum cover.
   c. Lockable, paintable.
   d. Color: Gray.
   e. Manufacturer and Product: TayMac; Type Multi-Mac.
3. Switches:
   a. Gasketed, cast-aluminum, incorporating external operator for internal switch.
   b. Mounting Screw: Stainless steel.

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c. Manufacturers and Products:
   1) Crouse-Hinds; DS-181 or DS-185.
   2) Appleton; FSK-1VTS or FSK-1VS.

2.07 MINI-POWER CENTER (MPC)

A. General: Transformer, primary and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 3R stainless steel enclosure.

B. Transformer:

1. Type: Dry, self-cooled, encapsulated.
2. Insulation: Manufacturer's standard, with UL 1561 temperature rise.
3. Full capacity, 2-1/2 percent voltage taps, two above and two below normal voltage.
4. Primary Voltage: As indicated on Drawings.
5. Secondary Voltage: As indicated on Drawings.

C. Panelboard: UL 489, fully-rated.

1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
2. Number and Breaker Ampere Ratings: Refer to Panelboard Schedule.

D. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

2.08 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

A. UL 489 listed for use at location of installation.

B. Minimum Interrupt Rating: As indicated on Drawings.

C. Thermal-magnetic, quick-make, quick-break, indicating type showing ON/OFF and TRIPPED indicating positions of operating handle.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Locking: Provisions for padlocking handle.

F. Enclosure: As specified under Part 3, Execution.

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G. Interlock: Enclosure and switch shall interlock to prevent opening cover with breaker in the ON position. Interlock shall be defeated by qualified maintenance personnel.

H. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

2.09 NONFUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Suitable for use with 75 degrees C or greater wire insulation system at NEC, 75 degrees C conductor ampacity.

D. Enclosure: As specified under Execution.

E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position. Interlock shall be defeated by qualified maintenance personnel.

F. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

2.10 PUSHBUTTONS, INDICATING LIGHTS, AND SELECTOR SWITCHES

A. Type: Heavy-duty, oiltight. Provide contact arrangements, colors, inscriptions, and functions as shown.

B. Contact Rating: 7,200 VA make, 720 VA break at 600V, NEMA ICS5 designation A600.

C. Unless otherwise shown, provide the following features:

1. Selector Switch Operating Lever: Standard.
2. Indicating Lights: Push-to-test, transformer-type.
3. Pushbutton Color:
   a. ON or START: Black.
   b. OFF or STOP: Red.

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4. Pushbuttons and selector switches lockable in OFF position where indicated.

D. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Letter Height: 7/64 inch.

E. Manufacturers and Products:

1. General Electric Co.; Type CR 104P.
2. Square D Co.; Type T.
3. Eaton; Type 10250T.

2.11 TERMINAL BLOCKS

A. Type: UL 1059. Compression screw clamp, with current bar providing direct contact with wire and yoke, with individual rail mounted terminals. Marking system shall permit use of preprinted or field-marked tags.

B. Yokes and Clamping Screws: Zinc-plated, hardened steel.

C. Rating: 600V ac.

D. Manufacturers:

1. Weidmuller, Inc.
2. Ideal.

2.12 MAGNETIC CONTROL RELAYS

A. NEMA ICS 2, Class A600 (600 volts, 10 amperes continuous, 7,200VA make, 720VA break), machine tool type with field convertible contacts.

B. Manufacturers and Products:

1. Eaton; Type M-600.
2. General Electric; Type CR120B.

2.13 TIME DELAY RELAY

A. Industrial Relay Rated: 150 volts, 5 amps continuous, (3,600 VA make, 360 VA break).

B. Solid-state electronic, field convertible ON/OFF delay.

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C. Two Form-C contacts (minimum).

D. Repeat accuracy plus or minus 2 percent.

E. Timer Adjustment: Multiple adjustable ranges, including 1 second to 60 seconds, unless otherwise shown.

F. Manufacturers:

1. Omron.
2. Eaton.
3. General Electric Co.

2.14 ELAPSED TIME METERS

A. Type: Synchronous motor driven, 0 hours to 99,999.9 hours range, nonreset, suitable for semiflush, panel mounting.

B. Manufacturers:

1. General Electric Co., Type 240, 2-1/2-inch BigLook.
2. Eagle Signal Controls; Bulletin 705.

2.15 SUPPORT AND FRAMING CHANNELS

A. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12-gauge.

B. All mounting and fastening hardware shall be Type 316 stainless steel.

C. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.

2.16 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment: Adhesive.

C. Color: Black, engraved to a white core, or as shown.

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D. Engraving:

1. Devices and Equipment: Name or tag shown, or as required.
2. Panelboards:
   a. Designation.
   b. Service voltage.
   c. Phases.
3. Minimum Requirement: Label metering and power distribution equipment, local control panels, junction boxes, motor controls, and transformers.

E. Letter Height:

1. Pushbuttons, Selector Switches, and Other Devices: 1/8 inch.
2. Equipment and Panelboards: 1/4 inch.

2.17 CONDUIT AND FITTINGS

A. Rigid Aluminum Conduit:

1. Meet requirements of NEMA C80.5 and UL 6A.
2. Material: Type 6063, copper-fill aluminum alloy.

B. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed, or direct sunlight exposure, and 90 degrees C insulated conductors.

C. PVC-Coated Rigid Aluminum Conduit:

1. Meet requirements of NEMA RN 1.
2. Material: Type 6063, copper-fill aluminum alloy.
   a. Meet requirements of NEMA C80.5 and UL 6A.
   b. Exterior Finish: PVC coating, 40 mils nominal thickness, bond to metal shall have tensile strength greater than PVC.
   c. Interior Finish: Urethane coating, 2 mils nominal thickness.
3. Threads: Factory coated with urethane.
4. Bendable without damage to either interior or exterior coating.

D. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Aluminum, with an extruded PVC jacket.

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E. Fittings:

1. Provide bushings, grounding bushings, conduit hubs, conduit bodies, couplings, unions, conduit sealing fittings, drain seals, drain/breather fittings, expansion fittings, and cable sealing fittings, as applicable.
2. PVC Conduit:
   a. Meet requirements of NEMA TC 3.
   b. Type: PVC, slip-on.
3. PVC-Coated Rigid Aluminum Conduit:
   a. Meet requirements of UL 514B.
   b. Fittings: As listed for rigid aluminum conduit.
   c. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC-coated by conduit manufacturer.
   d. Finish: 40-mil PVC exterior, 2-mil urethane interior.
   e. Overlapping pressure sealing sleeves.
   f. Conduit Hangers, Attachments, and Accessories: PVC-coated.
   g. Manufacturers:
      1) Robroy Industries.
      2) Ocal.
   h. Expansion Fitting Manufacturer and Product: Ocal; Ocal-Blue XJG.
4. Rigid Aluminum Conduit:
   a. General:
      1) Meet requirements of UL 514B.
      2) Type: Threaded, copper-free. Set screw fittings not permitted.
   b. Insulated Bushing:
      1) Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
      2) Manufacturer and Product: O-Z/Gedney; Type AB.
   c. Grounding Bushing:
      1) Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
      2) Manufacturer and Product: O-Z/Gedney; Type ABLG.
   d. Conduit Hub:
      1) Material: Cast aluminum, with insulated throat.
      2) UL listed for use in wet locations.
      3) Manufacturers and Products:
         a) O-Z/Gedney; Type CHA.
         b) Thomas & Betts; Series 370AL.
         c) Meyers; Series SA.

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e. Aluminum Conduit Bodies:
   1) Manufacturers and Products (For Normal Conditions):
      a) Appleton; Form 85 threaded unilets.
      b) Crouse-Hinds; Mark 9 or Form 7-SA threaded condulets.
      c) Killark; Series O electrolets.
   2) Manufacturers (for Hazardous Locations):
      a) Appleton.
      b) Crouse-Hinds.
      c) Killark.
f. Aluminum Couplings: As supplied by conduit manufacturer.
g. Aluminum Conduit Sealing Fitting Manufacturers and Products:
   1) Appleton; Type EYF-AL or EYM-AL.
   2) Crouse-Hinds; Type EYS-SA or EZS-SA.
   3) Killark; Type EY or EYS.
h. Type 316 Stainless Steel Drain Seal Manufacturers and Products:
   1) Appleton; Type EYDM-A.
   2) Crouse-Hinds; Type EYD-SA or EZD-SA.
i. Type 316 Stainless Steel Drain/Breather Fitting Manufacturers and Products:
   1) Appleton; Type ECDB.
   2) Crouse-Hinds; ECD.
j. Aluminum Expansion Fitting Manufacturers and Products:
   1) Deflection/Expansion Movement: Steel City; Type DF-A.
   2) Expansion Movement Only: Steel City; Type AF-A.
k. Aluminum Cable Sealing Fittings: To form watertight nonslip cord or cable connection to conduit.
   1) Bushing: Neoprene at connector entry.
   2) Manufacturer and Product: Appleton; CG-S.

5. Flexible Metal, Liquid-Tight Conduit:
   a. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
   b. Insulated throat and sealing O-rings.

2.18 CONDUIT ACCESSORIES

A. Duct Bank Spacers:

1. Type: Nonmetallic, interlocking, for multiple conduit sizes.
2. Suitable for all types of conduit.
3. Manufacturers:
   a. Underground Device, Inc.
   b. Carlon.

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B. Identification Devices:

1. Raceway Tags:
   a. Material: Permanent, Type 316 stainless steel.
   b. Shape: Round.
   c. Raceway Designation: Pressure stamped, embossed, or engraved.
   d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum 6 inches.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Identifying Letters: Minimum 1-inch high permanent black lettering imprinted continuously over entire length.

2.19 CONDUCTORS AND CABLES

A. Conductors 600 Volts and Below:

1. Conform to applicable requirements of NEMA WC 71, WC 72, and WC 74.
2. Conductor Type: All Other Circuits: Stranded copper.
3. Insulation: Type XHHW-2.
4. Flexible Cords and Cables:
   a. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
   b. Conform to physical and minimum thickness requirements of NEMA WC 70.

B. 600-Volt Rated Cable:

1. General:
   a. Type TC, multi conductor meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
   b. Permanently and legibly marked with manufacturer’s name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
   c. Suitable for installation in open air, in cable trays, or conduit.
   d. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
   e. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

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2. Type 1, Multiconductor or Single Conductor Control Cable:
   a. Conductors:
      1) 14 AWG, seven-strand tinned copper.
      2) Insulation: 15-mil PVC with 4-mil nylon.
      3) UL 1581 listed as Type XHHW-2 rated VW-1.
      4) Conductor group bound with spiral wrap of barrier tape.
      5) Color Code for Multiconductor Cables: In accordance with ICEA S-58-679, Method 1, Table 2.
3. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
4. Manufacturers:
   a. Okonite Co.
   b. Southwire.
   c. Belden.
5. Type 3, No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   a. Outer Jacket: 45 mils nominal thickness.
   b. Individual Pair Shield: 1.35 mils, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
   c. Dimension: 0.31-inch nominal outside diameter.
   d. Conductors:
      1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
      2) 20 AWG, seven-strand tinned copper drain wire.
      3) Insulation: 15 mils nominal PVC.
      4) Jacket: 4 mils nominal nylon.
      5) Color Code: Pair conductors black and red.
   e. Manufacturers: Okonite Co.
6. Type 8, Multi-Conductor Adjustable Frequency Drive Power Cable:
   a. Conductors:
      1) Class B, stranded coated copper.
      2) Insulation: 600-volt, UL Type XHHW-2.
      3) Grounding Conductors: Insulated stranded copper.
   b. Sheath:
      1) UL 1277 Type TC, 90 degrees C.
      2) Continuous shield, A1/polyester foil, drain wires, overall copper braid.
   c. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
   d. Manufacturers and Products:
      1) Alpha Wire.
      2) Belden; Classic VFD.
      3) LAPP USA.

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7. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:
   a. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-B.2-1 Category 6 requirements.
   b. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
   c. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
   d. NFPA 70 Plenum (CMP) rated, comply with flammability plenum requirements of NFPA 70 and NFPA 262.
   e. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
   f. Manufacturer and Product: Belden; 7953A.
8. Type FO, Multi-Mode Fiber Optic Cable:
   a. Fibers:
      1) 50-micron, graded-index for use in backbone and horizontal distribution subsystems, meets or exceeds the requirements of TIA 568-C.3 and TIA/EIA 492AAAD, including the following specifications:
      2) Maximum Mean Fiber Loss:
         a) 2.5 dB per km at 850 nm.
         b) 1.5 dB per km at 1,300 nm.
      3) Minimum OFL Bandwidth:
         a) OM3: Per TIA/EIA 455-204 and IEC 60793-1-49.
            (1) 3,500 MHz•km minimum at 850 nm.
            (2) 500 MHz•km minimum at 1,300 nm.
      4) Minimum EMB: 4,700 MHz•km minimum at 850 nm.
      5) Distance Capacity per IEEE 802.3:
         a) 100 Mbit Fast Ethernet: 2,000 m.
         b) 1 Gbit Ethernet: 1,000 m at 850 nm and 550 m at 1,300 nm.
         c) 10 Gbit Ethernet: OM4, 550 m at 850 nm.
      6) Macro-Bend Performance:
         a) Bend-insensitive fibers with following characteristics at 850 nm:
            (1) 15 mm Radius Mandrel, Two Turns: Induced attenuation less than 0.1 dB.
            (2) 7.5 mm Radius Mandrel, Two Turns: Induced attenuation less than 0.2 dB.

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b. Cable:
1) Type 50 OM3, Indoor/Outdoor Cable:
a) For indoor/outdoor underground conduit and building riser installations:
(1) Individual Fibers: 50 microns.
(2) Assembly:
(a) Distribution Style with core of individually tight-buffered fibers surrounded by nonmetallic sheath.
(b) Cable: Comply with ICEA S-104-696.
(c) Fiber Count:
(d) 12-strand or 6-strand, as shown.
(3) Protective Covering: Flame retardant outer jacket with pull string.
(4) NEC/UL Listing: OFNR.
(5) Manufacturers and Products:
(a) Corning Cabling Systems; FREEDM cable.
(b) Mohawk; Distribution Riser cable.
c. Connectors: LC Connectors.

C. Grounding Conductors:

1. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN insulation.
2. Direct Buried: Band stranded tinned copper.

D. Accessories:

1. Tape:
a. General Purpose, Flame Retardant: 7 mils, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
b. Flame Retardant, Cold and Weather Resistant: 8.5 mils, vinyl plastic, Scotch Brand 88.
c. Arc and Fireproofing:
1) 30 mils, elastomer.
2) Manufacturers and Products:
a) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
b) Plymount; Plyarc 53, with Plyglas 77 glass cloth tapebinder.

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2. Identification Devices:
   a. Sleeve-type, permanent, PVC, yellow or white, with legible machine-printed black markings.
   b. Manufacturer and Product: Raychem; Type D-SCE or ZH-SCE.
3. Connectors and Terminations:
   a. Nylon, Self-Insulated Crimp Connectors:
      1) Manufacturers and Products:
         a) Thomas & Betts; Sta-Kon.
         b) Burndy; Insulug.
         c) ILSCO.
4. Self-Insulated, Freespring Wire Connector (Wire Nuts):
   a. Plated steel, square wire springs.
   b. UL Standard 486C.
   c. Manufacturers and Products:
      1) Thomas & Betts.
      2) Ideal; Twister.
5. Cable Lugs:
   a. In accordance with NEMA CC 1.
   b. Rated 600 volts of same material as conductor metal.
   c. Uninsulated Crimp Connectors and Terminators:
      1) Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
      2) Manufacturers and Products:
         a) Thomas & Betts; Color-Keyed.
         b) Burndy; Hydent.
         c) ILSCO.
   d. Uninsulated, Bolted, Two-Way Connectors and Terminators:
      1) Manufacturers and Products:
         a) Thomas & Betts; Locktite.
         b) Burndy; Quiklug.
         c) ILSCO.
6. Cable Ties:
   a. Nylon, adjustable, self-locking, and reusable.
   b. Manufacturer and Product: Thomas & Betts; TY-RAP.
7. Heat Shrinkable Insulation:
   a. Thermally stabilized, crosslinked polyolefin.
   b. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

2.20 MOTORS

A. Three-Phase:

1. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

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2. Meet requirements of NEMA MG 1.
3. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.
4. Motors shall be specifically designed for use and conditions intended, with a NEMA design letter classification to fit application.
5. Lifting lugs on motors weighing 100 pounds or more.
6. Operating Conditions: Maximum ambient temperature not greater than 40 degrees C.
7. Horsepower Rating: As designated in motor-driven equipment specifications. Brake horsepower of the driven equipment at any operating condition shall not exceed motor nameplate horsepower rating, excluding any service factor.
8. Service Factor: 1.15 minimum at rated ambient temperature, unless otherwise shown.
9. Voltage and Frequency Rating: 460V ac, 60 Hz, unless otherwise indicated in motor-driven equipment specifications.
10. Suitable for full voltage starting. 100 hp and larger also suitable for reduced voltage starting with 65 percent or 80 percent voltage tap settings on reduced inrush motor starters.
11. Efficiency and Power Factor: Provide premium efficiency units, except for under 1 hp, multispeed, or short-time rated motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists. Provide standard power factor.
12. Insulation Systems: Unless otherwise indicated in motor-driven equipment specifications, Class B or Class F at nameplate horsepower and designated operating conditions, except EXP motors that shall be Class B with Class B rise.
13. Enclosures:
    a. TEFC: Furnish with a drain hole with porous drain/weather plug.
    b. Equipment Finish: Manufacturer’s standard.
14. Winding Thermal Protection:
    a. Thermostats:
        1) Bi-metal disk or rod type thermostats embedded in stator windings.
        2) Automatic reset contacts rated 120V ac, 5 amps minimum, opening on excessive temperature.
        3) Leads extending to separate terminal box for motors 100 hp and larger.
    b. Space Heaters:
        1) Provide winding space heaters with leads wired out to motor terminal box.
        2) Heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.

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15. Nameplates: In accordance with NEMA MG1.
16. Multispeed: Meet requirements for speeds, number of windings, and load torque classification indicated in the motor-driven equipment specifications.
17. Inverter Duty Motor:
    a. Motor supplied power by adjustable frequency drives shall be inverter duty-rated.
    b. Motor shall meet all applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.
    c. Motor shall be suitable for operation over entire speed range indicated.
    d. Provide forced ventilation where speed ratio is greater than published range for motor being installed. Provide and coordinate fan power supply and motor control requirements with associated drive.

B. Single-Phase:

1. Provide induction-type unit meeting NEMA MG1 requirements and suitable for application and mounting with the driven load. Motor shall be 115/230V ac, 60 Hz. Provide integral thermal protection and manufacturer's standard insulation system.
2. Horsepower Rating: As specified under motor-driven equipment specification.
3. Single-speed: Single-winding. Speed as specified under motor-driven equipment specification.
4. Two-speed: Two-winding; speeds as specified under motor-driven equipment specification.
5. Enclosure: Open drip-proof, unless otherwise noted.

C. Manufacturers:

1. General Electric.
2. Reliance Electric.
3. U.S. Electrical Motors.
4. Balder.

D. Factory Testing:

1. Tests:
    a. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
    b. Provide routine (production) tests on all motors in accordance with NEMA MG 1. Test multispeed motors at all speeds.

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c. For premium efficiency motors, test efficiency and power factor at 50, 75, and 100 percent of rated horsepower:
   1) In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraphs 12.54 and 12.57.
   2) For smaller motors, furnish a copy of a certified motor efficiency test report for identical motor.

2. Test Report Forms:
   a. Routine Tests: IEEE 112, Form A-1.
   b. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Paragraph (table) 12.57.

2.21 GROUNDING

A. Ground Rods: Provide copper-clad stainless steel with minimum diameter of 5/8-inch, and length of 10 feet.

B. Ground Conductors: As specified in Article Conductors and Cable.

C. Connectors:

1. Exothermic Weld Type:
   a. Outdoor Weld: Suitable for exposure to elements or direct burial.
   b. Indoor Weld: Utilize low-smoke, low-emission process.
   c. Manufacturers:
      1) Erico Products, Inc.; Cadweld and Cadweld Exolon.
      2) Thermoweld.
2. Compression Type:
   a. Compress-deforming type; wrought copper extrusion material.
   b. Single indentation for conductors 6 AWG and smaller.
   c. Double indentation with extended barrel for conductors 4 AWG and larger.
   d. Single barrels prefilled with oxide-inhibiting and antiseizing compound.
   e. Manufacturers:
      1) Burndy Corp.
      2) Thomas and Betts Co.
      3) ILSCO.
3. Mechanical Type:
   a. Split-bolt, saddle, or cone screw type; copper alloy material.
   b. Manufacturers:
      1) Burndy Corp.
      2) Thomas and Betts Co.

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2.22 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are located in Luminaire Schedule on Drawings.

B. Provide luminaires and components tested, listed, and labeled by UL, or other approved testing agency.

C. Provide luminaires with Illumination Engineering Society of North America (IESNA) formatted photometric files, ".ies" format, certified by the luminaire manufacturer for use with lighting software.

D. Luminaire Labels:

1. External label per ANSI C136.15.
2. Internal label per ANSI C136.22.

E. Wire Leads: Minimum 18 AWG.

F. Exterior Installations:

1. UL Labeled: SUITABLE FOR WET LOCATIONS.
2. Driver: Removable, prewired.
3. When factory-installed photocells are provided, entire assembly shall have UL label.

G. Steel Poles:

1. Minimum 11-gauge steel with minimum yield/strength of 48,000 psi and hot-dipped galvanized factory finish.
2. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
3. Tapered tubular members, either round in cross section or polygonal.
4. Provide one-piece pole shafts of welded construction with no bolts, rivets, or other means of fastening except as specifically approved.
5. Pole Markings: Approximately 3 feet to 4 feet above grade and include manufacturer, year of manufacture, top and bottom diameters, and length.
6. Base Covers: Structural quality hot-rolled carbon steel plate having a minimum yield of 36,000 psi.

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2.23 LOW VOLTAGE MOTOR CONTROL

A. General:

1. Make adjustments as necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors and motor ratings actually provided.
2. Controllers: NEMA ICS l, NEMA ICS 2, Class A.
3. Type: Electronic, providing integral overload, phase-loss, and phase-unbalance protection.
4. Control Transformer:
    a. Two winding, 120-volt secondary, primary voltage to suit.
    b. Two current-limiting fuses for primary circuit.
    c. One fuse in secondary circuit.
    d. Mount within starter unit.
5. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
6. Lifting lugs on all equipment and devices weighing over 100 pounds.
7. Operating Conditions:
    a. Ambient Temperature: Maximum 40 degrees C.
    b. Equipment to be fully rated without any derating for operating conditions listed above.
8. Equipment Finish:
    a. Electrocoating process applied over rust-inhibiting phosphated base coating.
    b. Exterior Color: Provide gray finish.
9. Phase Monitoring Relay: Where shown, provide three-phase monitoring relay to protect against low voltage, voltage unbalance, phase loss, and phase reversal.

B. Combination Full-Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for 22,000 amperes with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: As shown on equipment submittals.
4. Disconnect Type: Motor circuit protector.
5. Enclosure: As shown on equipment submittals.
6. Pilot Lights: Red—ON and Green—OFF.

C. Padlockable operating handle.

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D. Manufacturers:

1. Eaton.
2. General Electric.
3. Square D.
4. Allen-Bradley.

E. Low-Voltage Adjustable Frequency Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

2.24 LOCAL CONTROL PANELS

A. Enclosure:

1. NEMA 250, Type 4X, stainless steel.
2. Minimum Metal Thickness: 14-gauge.
3. Doors: Rubber gasketed with continuous hinge.
4. Size panels to adequately dissipate heat generated by equipment mounted in or on panel.
5. Mount internal and door-mounted devices as shown.
6. Manufacturers:
   a. Hoffman.
   b. H. F. Cox.

B. Functions: As shown on schematic diagram(s).

C. Wiring:

1. Power and Control Wiring:
   a. 600-volt class, insulated, stranded copper.
   b. Size: Minimum 14 AWG enclosed in either sheet metal raceway or plastic wiring duct.
2. Signal Circuit Wiring: Twisted shielded pairs minimum No. 16 AWG, separated at least 6 inches from power wiring.
3. Device Identification: Provide engraved plastic nameplates, adhesive attachment, white letters on black background.

PART 3 EXECUTION

3.01 GENERAL

A. Install materials and equipment in accordance with manufacturer’s instructions and recommendations.

B. Work shall comply with all applicable provisions of NECA 1.

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C. Install materials and equipment in hazardous areas in a manner acceptable to regulatory authority having jurisdiction for the class, division, and group of hazardous areas shown.

D. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.

3.02 DEMOLITION

A. General Demolition:
   1. Where shown, de-energize and disconnect nonelectrical equipment for removal by others.
   2. Where shown, de-energize, disconnect, and remove electrical equipment.
   3. Remove affected circuits and raceways back to serving panelboard or control panel. Where affected circuits are consolidated with others, remove raceways back to first shared condulet or box. Where underground or embedded raceways are to be abandoned, remove raceway to 1 inch below surface of structure or 12 inches belowgrade and restore existing surface.

3.03 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation.

B. Cap conduit runs during construction with manufactured seals.

C. Close openings in boxes or equipment during construction.

D. Energize space heaters furnished with equipment.

3.04 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.

B. Size:

   1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
      a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
   2. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.

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3. Mount box off wall using minimum 1/2-inch stainless steel channels.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Owner.
3. Light Switch: Install on lock side of doors.

D. Mounting Height:

1. General:
   a. Dimensions given to centerline of box.
   b. Where specified heights do not suit building construction or finish, mount as directed by Owner.
2. Switches: 48 inches above floor.
3. Receptacles:
   a. General Indoor Areas: 15 inches above floor.
   b. General Indoor Areas (Counter Tops): Install device plate bottom or side flush with top of splashback, or 6 inches above counter tops without splashback.
   c. Industrial Areas, Workshops: 48 inches above floor.
   d. Outdoor, All Areas: 24 inches above finished grade.

E. Install plumb and level.

F. Support boxes independently of conduit by attachment to building structure or structural member.

G. Box Type (Metal Raceway System): Cast aluminum.

3.05 JUNCTION AND PULL BOXES

A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.

B. Install pull boxes where necessary in raceway system to facilitate conductor installation.

C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

D. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.

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E. Use conduit bodies as junction and pull boxes where no splices are required and their use is allowed by applicable codes.

F. Installed boxes shall be accessible.

G. Do not install on finished surfaces.

H. Install plumb and level.

I. Support boxes independently of conduit by attachment to building structure or structural member.

J. At or Belowgrade:

1. Install boxes for belowgrade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

K. Mounting Hardware:

1. Noncorrosive Indoor Dry Areas: Aluminum.
2. Outdoor or Noncorrosive Indoor Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

L. Location/Type:

1. Indoor, Dry: NEMA 250, Type 1.
2. Indoor and Outdoor, Wet: NEMA 250, Type 4X stainless steel.
3. Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X, stainless steel.
4. Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.
5. Underground Conduit: Concrete.
6. Corrosive: NEMA 250, Type 4X, stainless steel.
7. Outdoor, Where Indicated Weatherproof (WP): NEMA 250, Type 3R.
8. Industrial Use in Areas Not Otherwise Classified: NEMA 250, Type 12, unless otherwise shown.

M. Install Drain/breather fittings in NEMA 250, Type 4 and Type 4X enclosures.

3.06 PRECAST HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with Excavation, and Trench Backfill Specifications.

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B. Do not install until final raceway grading has been determined.

C. Install such that raceways enter at nearly right angles and as near as possible to one end of wall, unless otherwise shown.

3.07 WIRING DEVICES

A. Switches:

1. Mounting Height: See Article Outlet and Device Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switches such that toggle is in up position when switch is on.

B. Receptacles:

1. Install with grounding slot down, except where horizontal mounting is shown, in which case install with neutral slot down.
2. Ground receptacles to boxes with grounding wire only.
3. Weatherproof Receptacles:
   a. Install in cast metal box.
   b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
5. Special-Purpose Receptacles: Install in accordance with manufacturer’s instructions.

3.08 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

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E. Types (Unless Otherwise Shown):

1. Outdoor: Weatherproof.
2. Indoor:
   a. Flush Mounted Boxes: Aluminum.
   b. Surface Mounted, Metal Boxes: Cast aluminum.

3.09 PANELBOARDS AND MINI-POWER CENTERS

A. Install securely, plumb, in-line and square with walls.

B. Install top of cabinet 6 feet above floor, unless otherwise shown.

C. Provide typewritten circuit directory for each panelboard.

D. Cabinet Location/Type:

1. Indoor Dry: NEMA 250, Type 1.
2. Wet or Outdoor: NEMA 250, Type 3R.
3. Industrial Use in Areas Not Otherwise Classified: NEMA 250, Type 12, unless otherwise shown.

3.10 CIRCUIT BREAKERS AND SWITCHES

A. Location and Enclosure Type:

1. Wet or Outdoor: NEMA 250, Type 4X stainless steel.
2. Corrosive: NEMA 250, Type 4X stainless steel.
3. Wet and Corrosive: NEMA 250, Type 4X stainless steel.
4. Indoor Dry, Industrial Use: NEMA 250, Type 12.
5. Indoor Dry, General Purpose: NEMA 250, Type 1.
6. Where Denoted WP: NEMA 250, Type 3R.

3.11 TERMINAL BLOCKS

A. Install for termination of control circuits entering or leaving equipment and local control panels.

3.12 SUPPORT AND FRAMING CHANNELS

A. Install where required for mounting and supporting electrical equipment and raceway systems.

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B. Channel Type:

1. Interior, Wet or Dry Corrosive Locations: Type 316 stainless steel.
2. Outdoor, Corrosive Locations: Type 316 stainless steel.
3. All Mounting and Attachment Hardware: Type 316 stainless steel.

C. Paint carbon steel channel cut ends prior to installation with zinc-rich primer.

3.13 NAMEPLATES

A. Provide identifying nameplate on all equipment.

3.14 CONDUIT AND FITTINGS

A. General:

1. Crushed or deformed raceways not permitted.
2. Maintain raceway entirely free of obstructions and moisture.
3. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
4. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
5. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
6. Group raceways installed in same area.
7. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
8. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
9. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.
10. Install watertight fittings in outdoor, underground, or wet locations.
11. Aluminum conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
12. Do not install raceways in concrete equipment pads, foundations, or beams.
13. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
14. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

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B. Installation in Cast-in-Place Structural Concrete:

1. Minimum cover 2 inches, including all fittings.
2. Conduit placement shall not require changes in reinforcing steel location or configuration.
3. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.
4. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns or beams, unless approved by Engineer.
5. Slabs and Walls:
   a. Trade size of conduit not to exceed one-fourth of the slab or wall thickness.
   b. Install within middle two-fourths of slab or wall.
   c. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
   d. Separate conduit 2 inches and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
   e. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
   f. Separate conduit by a minimum six times the outside dimension of expansion and deflection fittings at expansion joints.
   g. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.
6. Columns and Beams:
   a. Trade size of conduit not to exceed one-fourth of beam thickness.
   b. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

C. Conduit Application:

1. Diameter:
   a. Interior Minimum: 3/4 inch.
   b. Exterior Minimum: 3/4 inch.
2. Outdoor, Exposed: Rigid aluminum conduit.
3. Indoor, Exposed: Rigid aluminum conduit.
4. Indoor, Concealed (Not Embedded in Concrete): Rigid aluminum conduit.
5. Underground:
   a. PVC Schedule 40 conduit in concrete encased ductbank.
   b. Transition from Underground: Elbows shall be PVC coated aluminum, nonconcrete encased.
6. Corrosive Areas: Rigid aluminum conduit.
7. Classified Areas: Rigid aluminum conduit.

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D. Connections:

1. For motors-, wall-, or ceiling-mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:
   a. General: Flexible aluminum, liquid-tight conduit.
   b. Wet or Corrosive Areas: Flexible aluminum liquid-tight.
   c. Length: 18 inches minimum, 60 inches maximum, sufficient to allow movement or adjustment of equipment.
2. Outdoor areas, process areas exposed to moisture, and areas required to be oiltight and dust-tight: Flexible aluminum, liquid-tight conduit.
3. Transition From Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.
4. Under Equipment Mounting Pads: PVC-coated rigid steel conduit.

E. Penetrations:

1. Make at right angles, unless otherwise shown.
2. Notching or penetration of structural members, including footings and beams, not permitted.
3. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack.
4. Entering Structures:
   a. General: Seal raceway at the first box or outlet with oakum or expandable plastic compound to prevent the entrance of gases or liquids from one area to another.
   b. Concrete Roof or Membrane Waterproofed Wall or Floor: Provide watertight seal.
   c. Corrosive-Sensitive Areas:
      1) Seal all conduit passing through room walls.
      2) Seal conduit entering equipment panelboards and field panels containing electronic equipment.
      3) Seal penetration with silicone type sealants.
   d. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
   e. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
      1) Provide watertight entrance seal device.
      2) Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint on each side.
   f. Handholes:
      1) Metallic Raceways: Provide insulated grounding bushings.
      2) Nonmetallic Raceways: Provide bell ends flush with wall.

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F. Support:

1. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 8 feet. Do not support from piping, pipe supports, or other raceways.
2. Application/Type of Conduit Strap:
   a. Rigid Aluminum Conduit: Type 316 stainless steel.
   b. PVC-Coated Aluminum Conduit: Type 316 stainless steel.
   c. Nonmetallic Conduit: Nonmetallic or PVC-coated aluminum.
3. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
   a. Concrete or Brick: Type 316 stainless steel expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
   b. Steelwork: Type 316 stainless steel machine screws.
   c. Location/Type of Hardware:
      1) Dry, Noncorrosive Areas: Type 316 stainless steel.
      2) Wet, Noncorrosive Areas: Type 316 stainless steel.
      3) Corrosive Areas: Type 316 stainless steel.

G. Bends:

1. Install concealed raceways with a minimum of bends in the shortest practical distance.
2. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
3. Install with symmetrical bends or cast metal fittings.
4. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
5. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
6. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run and raceways are same size.
7. PVC Conduit:
   a. Bends 30 Degrees and Larger: Provide factory-made elbows.
   b. 90-Degree Bends: Provide rigid steel elbows, PVC coated where direct buried.
   c. Use manufacturer’s recommended method for forming smaller bends.
8. Flexible Conduit: Do not make bends with radii less than factory 90 degree elbows of the same trade size.

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H. Expansion and Deflection Fittings: Provide on all raceways at structural expansion joints and in long tangential runs.

I. PVC Conduit:

1. Solvent Welding:
   a. Provide manufacturer recommended solvent; apply to all joints.
   b. Install such that joint is watertight.
2. Adapters:
   a. PVC to Metallic Fittings: PVC terminal type.
   b. PVC to Rigid Metal Conduit: PVC female adapter.
3. Belled-End Conduit: Bevel the unbelled end of the joint prior to joining.

J. PVC-Coated Aluminum Conduit:

1. Install in accordance with manufacturer's instructions.
2. All tools and equipment used in the cutting, bending, threading, and installation of PVC-coated rigid aluminum conduit shall be designed to limit damage to the PVC coating.
3. Provide PVC boot to cover all exposed threading.

K. Termination at Enclosures:

1. Cast Aluminum Enclosure: Provide manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
2. Nonmetallic, Cabinets, and Enclosures: Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
3. Sheet Metal Boxes, Cabinets, and Enclosures:
   a. Aluminum Conduit:
      1) Provide one lock nut each on inside and outside of enclosure.
      2) Install grounding bushing.
      3) Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure.
      4) Install insulated bushing on ends of conduit where grounding is not required.
      5) Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
      6) Utilize sealing locknuts or threaded hubs on outside of NEMA 3R and NEMA 12 enclosures.
      7) Terminate conduits with threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.

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b. Flexible Aluminum Conduit: Provide two-screw type, insulated, stainless steel connectors.
c. PVC Schedule 40 Conduit: Provide PVC terminal adapter with locknut.

4. Free-Standing Enclosures:
   a. Terminate metal conduit entering bottom with grounding bushing; provide a grounding jumper extending to equipment ground bus or grounding pad.
   b. Terminate PVC conduit entering bottom with bell end fittings.

L. Underground Raceways:

1. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.
2. Cover: Maintain minimum 18 inches cover above conduit, unless otherwise shown.
3. Make routing changes as necessary to avoid obstructions or conflicts.
4. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
5. Union type fittings not permitted.
6. Spacers:
   a. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in a trench.
   b. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
7. Support conduit so as to prevent bending or displacement during backfilling.
8. Installation with Other Piping Systems:
   a. Crossings: Maintain minimum 12-inch vertical separation.
   b. Parallel Runs: Maintain minimum 12-inch separation.
   c. Installation over valves or couplings not permitted.
9. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.
10. Provide deflectional/expansion fittings in conduit runs that exit building or structure belowgrade.
11. Backfill: Do not backfill until inspected by Owner.

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M. Empty Raceways:

1. Provide permanent, removable cap over each end.
2. Provide PVC plug with pull tab for underground raceways with end bells.
3. Provide nylon pull cord.
4. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

N. Identification Devices:

1. Raceway Tags:
   a. Identify origin and destination.
   b. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed raceway, whether in ceiling space or surface mounted.
   c. Provide nylon strap for attachment.
2. Warning Tape: Install approximately 12 inches above or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of runs.

3.15 CONDUCTORS AND CABLES

A. Conductor storage, handling, and installation shall be in accordance with manufacturer’s recommendations.

B. Do not exceed manufacturer’s recommendations for maximum pulling tensions and minimum bending radii.

C. Conduit system shall be complete prior to drawing conductors. Lubricate prior to pulling into conduit. Lubrication type shall be as approved by conductor manufacturer.

D. Terminate all conductors and cables, unless otherwise shown.

E. Do not splice conductors, unless specifically indicated or approved by Engineer.

F. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches.

G. Wiring within Equipment and Local Control Panels: Remove surplus wire, dress, bundle, and secure.

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H. Power Conductor Color Coding:

1. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 inches to 2 inches wide.
2. No. 8 AWG and Smaller: Provide colored conductors.
3. Colors:
   a. Neutral Wire: White.
   b. Live Wires, 120/240-Volt, Single-Phase System: Black, red.
   c. Live Wires, 120/208-Volt, Three-Phase System: Black, red, or blue.
   d. Live Wires, 277/480-Volt, Three-Phase System: Brown, orange, or yellow.
   e. Ground Wire: Green.

I. Circuit Identification:

1. Circuits Appearing in Circuit Schedules: Identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
2. Circuits Not Appearing in Circuit Schedules: Assign circuit name based on device or equipment at load end of circuit. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
3. Method: Identify with sleeves. Taped-on markers or tags relying on adhesives not permitted.

J. Connections and Terminations:

1. Install wire nuts only on both solid conductors.
2. Install wire nuts for instrumentation and control circuit conductors.
3. Tape insulate all uninsulated connections.
4. Install crimp connectors and compression lugs with tools approved by connector manufacturer.

K. Fiber Optic Cable:

1. Specified fiber counts, routing, origination, and terminating points are indicated on Drawings.
2. Installation by BICSI certified installer.
3. Install cables in accordance with manufacturer’s requirements.

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4. Install cable directly from shipping reels. Ensure that cable is:
    a. Not dented, nicked, or kinked.
    b. Not subjected to pull stress greater than manufacturer's specification.
    c. Not bent to a radius below manufacturer's minimum bend radius.
    d. Not subjected to treatment that may damage fiber strands during installation.
5. Cables per Conduit or Innerduct: In accordance with NFPA 70 NEC conduit fill limitations. One cable per innerduct maximum.
6. Splices: Install fiber optic cables in unspliced lengths between fiber distribution units. Do not splice.
7. Connector:
    a. Insertion loss no greater than:
        1) Multi-mode Connections: 0.5 dB maximum.
        2) Single-mode Connections: 0.4 dB maximum.
8. Identification:
    a. Identify cable on both ends, in access holes, and pull points.
    b. In accordance with TIA 606.
9. Arrange cable, equipment, and hardware to provide neat appearance and accessibility for servicing.
10. Access Spaces:
    a. Provide supports for cables in access spaces and hand holes at minimum every 2 feet.
    b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

L. Fiber Optic Cable Terminations:

1. In accordance with TIA 568-C.3.
2. Fan out fiber cable to allow direct connectorization of connectors.
    a. Sleeve over individual fibers with transparent furcation tubes.
    b. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.
3. Break-out Kits:
    a. Terminate cables using manufacturer-supplied break-out kits.
    b. Terminate in accordance with manufacturer's recommendations.
4. Slack:
    a. Network Racks and FDUs: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
5. Connectors: Terminate 100 percent of the fibers in each cable to specified connector.

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3.16 GROUNDING

A. Grounding shall be in compliance with NFPA 70 and as shown.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.

D. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

F. Equipment Grounding Conductors: Provide in all conduits containing power conductors and control circuits above 50 volts.

G. Ground Rods: Install full length with conductor connection at upper end. Install one ground rod in each handhole.

3.17 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

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G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. Use minimum 5/16-inch diameter bolt.

3.18 MOTOR GROUNDING

A. Connect equipment grounding conductor installed in motor feeder raceway to motor frame. In addition, connect the motor frame to the nearest ground grid using appropriately sized bare tinned copper conductor.

B. Motors Less than 10 hp: Furnish compression, spade-type terminal connected to conduit box mounting screw.

C. Motors 10 hp and Above: Tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

D. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.19 LOW VOLTAGE MOTOR CONTROL

A. Install equipment in accordance with NEMA ICS 2.3 and manufacturer’s instructions and recommendations.

B. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers. Adjust to approximately 11-times motor rated current.

C. Select and install overload relay heaters or adjust electronic overload protection after the actual nameplate full-load current rating of motor has been determined.

3.20 FIELD QUALITY CONTROL

A. General:

1. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.
2. Test instrument calibration shall be in accordance with NETA ATS.

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3. Perform inspection and electrical tests after equipment has been installed.
4. Perform tests with apparatus de-energized whenever feasible.
5. Inspection and electrical tests on energized equipment are to be:
    a. Scheduled with Engineer and Owner prior to de-energization.
    b. Minimized to avoid extended period of interruption to the operating plant equipment.

B. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Adjust mechanisms and moving parts for free mechanical movement.

E. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

F. Verify nameplate data for conformance to Contract Documents.

G. Realign equipment not properly aligned and correct unlevelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.

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3. Damaged electrical equipment.

M. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer, door and panel sections having damaged surfaces.
5. Replace missing or damaged hardware.

N. Provide certified test report(s) documenting the successful completion of specified testing. Include field test measurement data.

O. Test the following equipment and materials:

1. Conductors: Insulation resistance, No. 4 and larger only.
2. Panelboards, switches, and circuit breakers.
3. Motor controls.
4. Grounding electrodes.
5. Motors.

P. Controls:

1. Test control and signal wiring for proper termination and function.
2. Test local control panels and other control devices for proper terminations, configuration and settings, and functions.
3. Demonstrate control, monitoring, and indication functions in presence of Owner and Engineer.

Q. Balance electrical load between phases on panelboards and mini-power centers after installation.

R. Voltage Testing:

1. When installation is complete and facility is in operation, check voltage at point of termination of electric utility supply system to Project.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage for 24 continuous hours.
4. If unbalance exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded conditions more than plus or minus 4 percent of nominal, make written request to electric utility to correct condition.

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5. If corrections are not made, obtain written statement from a responsible electric utility official that voltage variations and/or unbalance are within their normal standards.

S. Equipment Line Current:

1. Check line current in each phase for each piece of equipment.
2. If electric utility makes adjustments to supply voltage magnitude or balance, make line current check after adjustments are made.

END OF SECTION

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SECTION 26 29 23
LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 REFERENCES

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

1. Electronic Industries Alliance (EIA): 359-A-1, Special Colors.
2. Hydraulic Institute Standards (HIS).
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. MG 1, Motors and Generators.
   d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.
5. National Fire Protection Association (NFPA): 79, Electrical Standard for Industrial Machinery.

B. Refer to Specification Section 40 90 01, Instrumentation and Control for Process Systems, and all associated Supplements for additional Instrumentation and Control Panel requirements.

1.02 DEFINITIONS

A. Terms that may be used in this section:

1. AFD: Adjustable frequency drive.
2. CMOS: Complementary metal oxide semiconductor.
3. CSI: Current source inverter.
4. EMU: Energy monitoring unit.
5. GTO: Gate turn-off thyristor.
6. MPR: Motor protection relay.
7. MTBF: Mean time between failure.
8. PWM: Pulse width modulation.

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9. ROM: Read only memory.
10. RTD: Resistance temperature detector.
11. RTU: Remote Telemetry Unit.
12. Rated Load: Load specified for equipment.
13. Rated Speed: Nominal rated (100 percent) speed specified for equipment.
14. TDD: Total demand distortion.
15. THD: Total harmonic distortion.
16. TTL: Transistor transistor logic.

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Composite drive/motor efficiency (CE) is defined as ratio of motor shaft kW to drive input kW. AFD system minimum requirements:
   a. At 60-Hz drive output and 100 percent load, CE equals 92 percent.
   b. At 50-Hz drive output and 60 percent load CE equals 89 percent.
   c. At 40-Hz drive output and 30 percent load CE equals 84 percent.
   d. At 30-Hz drive output and 12.5 percent load CE equals 77 percent.
2. Rated Continuous Operation Capacity: Not less than 1.15 times full load current rating of driven motor, as indicated on motor nameplate, and suitable for continuous operation at continuous overload which may be imposed on motor by driven pump operating over specified speed range.

B. Design Requirements:

1. Drive system consisting of adjustable frequency controller, drive motor, auxiliary items, and components necessary for complete operating system.
2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
3. Furnish AFDs rated on basis of actual motor full load nameplate current rating times the service factor.
4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using pulse-width-modulation (PWM) technique to produce adjustable frequency output.
5. System rated for continuous industrial duty and suitable for use with NEMA MG 1, Design B motors.

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6. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for drive system.
7. Incoming Line Reactor: Design to minimize harmonic distortion on incoming power feeder.
8. Drive manufacturer shall be responsible for assuring the AFD supplied is compatible with the motor being supplied under other Specification sections.

1.04 SUBMITTALS

A. Action Submittals:

1. Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.
2. AFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise including justification for proposed deviation from specified values. Include motor manufacturer's certification motor insulation will withstand long-term overvoltages caused at motor terminals due to specified output pulse data or proposed deviation from this data.
3. Data on shelf life of "dc link" capacitor.
4. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
5. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.
6. Controller, reactor, harmonic filter, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.
7. Maximum heat dissipation from enclosure.
8. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
9. Complete system operating description.
10. Complete system schematic (elementary) wiring diagrams.
11. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.
12. See Specification Section 40 90 01, Instrumentation and Control for Process Systems, and all associates supplements, for additional submittal requirements.

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13. Outdoor AFD Enclosure Heating/Cooling Requirements:
    a. Submit a detailed spreadsheet indicating each component within the control panel and it's "Heat Load" (in watts) at full load (for cooling calculations) and operating (partial) load (for heating calculations).
    b. Submit heating and cooling calculations; based on panel location; to maintain 40 degrees F in winter and 105 degrees F (or 10 degrees below the lowest rated operating temperature of the lowest rated device, whichever is less) in summer, unless otherwise noted.
    c. Submit the equations used to calculate heating and cooling load of the control panels.
    d. See Section 40 90 01, Instrumentation and Control for Process Systems, and all associates supplements, for additional heating and cooling requirements.
14. One-line diagram of system, including component ratings.
15. Description of diagnostic features being provided.
16. Descriptive literature for control devices such as relays and timers.
17. Itemized bill-of-materials listing system components.
18. Description MPR being furnished or how these functions are accomplished within drive system.

B. Informational Submittals:

1. Statement of Supplier qualifications.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Factory functional test reports.
5. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B, showing rated load, rated speed efficiency meeting or exceeding specified values; motors not as specified will be rejected.
6. Field test reports.
7. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
8. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
9. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
10. Manufacturer's Certificate of Proper Installation.

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1.05 QUALITY ASSURANCE

A. Supplier: Minimum 5 years' experience in furnishing similar size and type adjustable frequency, controlled speed, drive systems.

1.06 EXTRA MATERIALS

A. Furnish for Each Drive Unit:

1. Complete set of components likely to fail in normal service.
2. Plug-in subassemblies.
3. Printed circuit boards.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. Allen-Bradley.

2.02 SERVICE CONDITIONS

A. Ambient Operating Temperature: 32 degrees F to 104 degrees F.

B. Storage Temperature: Minus 40 degrees F to 158 degrees F.

C. Humidity: 0 percent to 95 percent relative (noncondensing).

D. Altitude: 0 foot to 3,300 feet.

E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.03 COMPONENTS

A. Where shown on Drawings, adjustable frequency drives, shall be Variable Torque (VT) with the following features:

1. The AFD shall be six-pulse or equivalent rated for 480V ac. The AFD shall provide microprocessor-based control for three-phase induction motors. The controller's full load output current rating shall be based on 50 degrees C ambient and no less than a 3.6 kHz switching frequency to reduce motor noise and avoid increased motor losses. Drive shall have been tested to and UL listed as conforming to the requirements of UL508C at rated load currents and ambient temperature per this

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specification. Drive shall have a UL listed interrupting rating of 65 kAIC.

2. The AFD shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. Adjustable Current Source AFD is not acceptable. Insulated Gate Bipolar Transistors (IGBT's) shall be used in the inverter section. Bipolar Junction Transistors, GTO's or SCR's are not acceptable. The AFD shall run at the above listed switching frequency.
3. The AFD shall have an efficiency at full load and speed that exceeds 95 percent. The efficiency shall exceed 90 percent at 50 percent speed and load. The AFDs shall maintain the line side displacement power factor at no less than 0.96, regardless of speed and load.
4. 6 pulse drive shall include the following protective features, as a minimum: Input line fuses, Metal Oxide Varistor (MOV), and Input choke rated 7.5 percent of rated line current.
5. The AFDs shall have a one minute overload current rating of 110 percent for variable torque loads.
6. The AFDs shall be capable of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a horsepower and current rating within the capacity of the AFD.
7. The AFD shall be able to start into a spinning motor. The AFD shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the AFD shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor to the preset speed.
8. Standard operating conditions shall be:
    a. Incoming Power: Three phase, 480V ac (plus 10 percent to minus 10 percent) and 60 Hz (plus or minus 5 Hz) power is converted to a fixed potential dc bus level. Maximum input voltage unbalance shall be 0.5 percent as defined in NEMA MG 1 section 14.35.2.
    b. Frequency stability of plus or minus 0.05 percent for 24 hours with voltage regulation of plus or minus 1 percent of maximum rated output voltage.
    c. Speed regulation of plus or minus 0.5 percent of base speed.
    d. Load inertia dependent carry over (ride through) during utility loss.
    e. Insensitive to input line rotation.
    f. Humidity: 0 percent to 95 percent (noncondensing and noncorrosive).
    g. Altitude: 0 feet to 3,300 feet (1,000 meters) above sea level.
    h. Ambient Temperature: 0 degrees C to 50 degrees C.
    i. Storage Temperature: Minus 40 degrees C to 60 degrees C.

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9. Control Functions:
    a. Frequently accessed AFD programmable parameters shall be adjustable from a digital operator keypad located on the front of the AFD. The AFD shall have a 3-line alphanumeric programmable display with status indicators. Keypads must use plain English words for parameters, status, and diagnostic messages. Keypads that are difficult to read or understand are not acceptable, and particularly those that use alphanumeric code and tables. Keypads shall be adjustable for contrast with large characters easily visible in normal ambient light.
    b. Standard advanced programming and trouble-shooting functions shall be available by using a personal computer's USB port and Windows™ based software. In addition the software shall permit control and monitoring via the AFD's USB port. The manufacturer shall supply a CD/DVD with the required software. An easily understood instruction manual and software help screens shall also be provided. The computer software shall be used for modifying the drive setup and reviewing diagnostic and trend information as outlined in this section.
    c. The operator shall be able to scroll through the keypad menu to choose between the following:
        1) Monitor.
        2) Operate.
        3) Parameter setup.
        4) Actual parameter values.
        5) Active faults.
        6) Fault history.
        7) LCD contrast adjustment.
        8) Information to indicate the standard software and optional features software loaded.
    d. The following setups and adjustments, at a minimum, are to be available:
        1) Start command from keypad, remote or communications port.
        2) Speed command from keypad, remote or communications port.
        3) Motor direction selection.
        4) Maximum and minimum speed limits.
        5) Acceleration and deceleration times, two settable ranges.
        6) Critical (skip) frequency avoidance.
        7) Torque limit.
        8) Multiple attempt restart function.
        9) Multiple preset speeds adjustment.
        10) Catch a spinning motor start or normal start selection.

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11) Programmable analog output.
12) DC brake current magnitude and time.
13) Proportional/Integral/Differential (PID) process controller.

10. The AFDs shall have the following common system interface input requirements:
    a. Inputs: A minimum of six programmable digital inputs, two analog inputs and serial communications interface shall be provided with the following available as a minimum.
        1) Remote manual/auto.
        2) Remote start/stop.
        3) Remote preset speeds.
        4) Remote external trip.
        5) Remote fault reset.
        6) Process control speed reference interface, 4 mA dc to 20 mA dc (two total).
        7) Potentiometer and 0V dc to 10V dc speed reference interface (two total).
        8) USB programming and operation interface port.
        9) RJ-45 Ethernet port for communication via the Allen-Bradley Ethernet/IP protocol. This shall enable monitoring of the AFD to the SCADA network.
            a) The digital communication port is for monitoring of the AFD data only.
            b) The AFD shall not be controlled remotely via the digital communication port.
    b. This shall not replace the need for control functions or status functions (as indicated above under “External I/O Interfaces”).
    c. Outputs: A minimum of two discrete programmable digital outputs, one programmable open collector output, and two programmable analog outputs shall be provided, with the following available at minimum.
        1) Programmable relay outputs with two sets of Form C contacts for each, selectable with the following available at minimum:
            a) Fault.
            b) Run.
            c) Remote.
            d) Jogging.
            e) At speed.
            f) In torque limit.
            g) Motor rotation direction opposite of commanded.
            h) Over-temperature.

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d. Programmable open collector output with available 24V dc power supply and selectable with the following available at minimum:
   1) Fault.
   2) Run.
   3) Ready.
   4) Jogging.
   5) At speed.
   6) In torque limit.
   7) Motor rotation direction opposite of commanded.
   8) Over-temperature.

e. Programmable analog output signal, selectable with the following available at minimum:
   1) Output current.
   2) Output frequency.
   3) Motor speed.
   4) Motor torque.
   5) Motor power.
   6) Motor voltage.
   7) DC link voltage.

11. Monitoring and Displays:

a. The AFD display shall be a LCD type capable of displaying three lines of text and the following status indicators:
   1) Run.
   2) Forward.
   3) Stop.
   4) Ready.
   5) Alarm.
   6) Fault.
   7) Local.
   8) Panel.
   9) Remote.
   10) Hand.
   11) Auto.
   12) Off.

b. Provide 30 mm LED indicating lights for the following:
   1) Control power on.
   2) Pump / Motor enable.
   3) Pump / Motor on.
   4) Pump / Motor off.
   5) Low level shut down.
   6) MAS fault (if applicable).
   7) Drive fault.

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c. The AFD keypad shall be capable of displaying the following monitoring functions at a minimum:
   1) Output frequency.
   2) Output speed.
   3) Motor current.
   4) Motor torque.
   5) Motor power.
   6) Motor voltage.
   7) DC-link voltage.
   8) Heatsink temperature.
   9) Total operating days counter.
   10) Operating hours (with reset function).
   11) Total megawatt hours.
   12) Megawatt hours (with reset function).
   13) Voltage level of analog input.
   14) Current level of analog input.
   15) Digital inputs status.
   16) Digital and relay outputs status.
   17) Motor temperature rise, percentage of allowable.

12. Protective Functions:
   a. The AFD shall include the following protective features at minimum:
      1) Over-current.
      2) Over-voltage.
      3) Inverter fault.
      4) Under-voltage.
      5) Phase loss.
      6) Output phase loss.
      7) Under-temperature.
      8) Over-temperature.
      9) Motor stalled.
      10) Motor over-temperature.
      11) Motor under-load.
      12) Logic voltage failure.
      13) Microprocessor failure.
      14) dc injection braking.
   b. The AFD shall provide ground fault protection during power-up, starting, and running. AFD with no ground fault protection during running are not acceptable.
13. Diagnostic Features:
   a. Fault History:
      1) Record and log faults.
      2) Indicate the most recent first, and store up to nine faults.

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14. Optional features to be included in the AFD:
    a. HMCP or thermal magnetic breaker to provide a disconnect means. Operating handle shall be flange mounted. The disconnect shall not be mounted on the door. The handle position shall indicate ON, OFF, and TRIPPED condition. The handle shall have provisions for padlocking in the OFF position with at least three padlocks. Interlocks shall prevent unauthorized opening or closing of the AFD door with the disconnect handle in the ON position. Door handle interlock can be defeated by qualified maintenance personnel.
    b. ac output contactor to provide a means for positive disconnection of the drive output from the motor terminals.
    c. Laminated plastic nameplate engraved with user's identifying name or number for oversize enclosures.
    d. 120V ac control to allow AFD to interface with remote dry contacts.
    e. Motor dv/dt filter for use on motor cable runs exceeding 100 feet for motors with a peak voltage insulation rating less than 1,600V ac.
        1) A properly sized line reactor shall be installed at the AFD output to reduce dv/dt levels and the resultant peak voltage overshoots at the motor terminals.

B. Minimum Operator Interface Device Requirements (See Drawings and Section 40 90 01, Instrumentation and Control for Process Systems, for additional requirements):

1. The AFD shall be furnished with a 30.5 mm, NEMA 4/13, push-to-test LED pilot light with a white (for 120V ac control power) or blue (for 24V dc control power) lens indicating "Control Power OK".
2. The AFD shall be furnished with a 30.5 mm, NEMA 4/13, three-position, maintained-contact selector switch for "Run-Off-Remote".
3. The AFD shall be furnished with a 30.5 mm, NEMA 4X, red, large mushroom head, maintained-contact push button for "Emergency Stop" (if applicable, see wiring diagrams).
4. The AFD shall be furnished with a 30.5 mm, NEMA 4/13, push-to-test LED pilot light with a red lens indicating "Running".
5. The AFD shall be furnished with a 30.5 mm, NEMA 4/13, push-to-test LED pilot light with a green lens indicating "Stopped".
6. The AFD shall be furnished with a 30.5 mm, NEMA 4/13, push-to-test LED pilot light with a red lens indicating "Emergency Stop Depressed" (if applicable, see wiring diagrams).

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7. The AFD shall be furnished with a 30.5 mm, NEMA 4/13, push-to-test LED pilot light with a red lens indicating “AFD Fault”.
8. The AFD shall be furnished with a 30.5 mm, NEMA 4/13, potentiometer with a variable impedance to match the AFD requirements, scaled for 0 percent to 100 percent.
9. The AFD shall be furnished with a 30.5 mm, NEMA 4X, black, flush-head, momentary-contact push button indicating “AFD Reset”.
    a. If an alarm condition is detected (“Emergency Stop Depressed”, “AFD Fault”, etc.), the corresponding AFD shall be locked out from operation by each alarm condition individual hard wired latching circuit. When a corresponding alarm condition is present, it shall illuminate its corresponding pilot light (latched in with the latching circuit). The AFD may be restored to service once the corresponding alarm has cleared and the “AFD Reset” push button has been depressed.

C. Minimum External I/O Interfaces (See Drawings for additional requirements):

1. AFD shall accept the following “Dry Contact” contact closures for the following discrete inputs:
    a. “Remote Start/Stop”.
    b. “Safety Interlocks / Equipment Enable” (Equipment may be for fan, mixer or pump).
    c. “External Interlocks” as required (See Drawings for additional requirements).
    d. “Equipment Reset” (Equipment may be for fan, mixer or pump).
2. AFD shall have the following relay “Dry Contacts” rated at a minimum of 2 amps at 120V ac for the following discrete outputs:
    a. “AFD Fault”.
    b. “AFD Running”.
    c. “Emergency Stop Depressed” status.
    d. “Reset Depressed” status.
    e. See Drawings for additional requirements.
3. AFD shall accept an isolated 4 mA dc to 20 mA dc analog input signal for remote speed reference. Furnish type “SS-2” surge suppressor for analog input signal per Section 40 90 01, Instrumentation and Control for Process Systems, and all associated Supplements requirements.
4. AFD shall have an isolated 4 mA dc to 20 mA dc analog output signal for remote speed feedback. Furnish type “SS-2” surge suppressor for analog output signal per Section 40 90 01, Instrumentation and Control for Process Systems, and all associated Supplements requirements.
5. The AFD shall be furnished with an Allen-Bradley Ethernet/IP Protocol module with an RJ-45 Ethernet jack for interface to the Plant SCADA network. Furnish type “SS-5” surge suppressor for digital

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communication signal per Section 40 90 01, Instrumentation and Control for Process Systems, and all associated Supplements requirements.

D. Alarm Conditions: Each alarm condition shall illuminate its respective pilot light in a latching circuit and lock out the operation of the respective AFD. The operator shall be reset when the operator depresses the AFD “Reset” push button.

E. Enclosure:

1. NEMA 250, Type 4, stainless steel, freestanding, enclosure for mounting on a stanchion, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on Drawings.
2. Furnish drive complete with cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, alphanumeric keypad and display, and operator’s controls.
3. Wire drive from below for power and control wiring.
4. Temperature Control:
   a. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
   b. Furnish self-contained, sealed (NEMA 4X) cooling system with air filters if required to dissipate heat.
   c. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.
      1) In humid areas, seasonally increase the setpoint to reduce condensation that results when nighttime temperatures fall below the dew point.
   d. For panels outdoors or in uncooled areas, furnish thermostatically controlled cooling system to maintain temperature either below 104 degrees F or ten degrees below the lowest temperature rating of any device housed within the enclosure, whichever is lower. Cooling system shall maintain the NEMA rating of the enclosure.
      1) If the device (within the control panel) with the lowest maximum temperature rating exceeds the calculated interior temperature of the control panel by 10 degrees F, then no cooling shall be required.
         a) Example: If five devices have the upper temperature threshold of the following:
            (1) 160, 175, 180, 200 and 220 degrees F; the equipment with the lowest temperature rating

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(160 degrees F) would be used to determine if cooling is required. If the interior ambient temperature of the control panel is determined to be 150 degrees F or less with the solar load and ambient outdoor temperature of 115 degrees F, then no cooling shall be required. If the interior panel temperature were determined to be greater than 150 degrees F, then cooling shall be required.

e. Calculate and submit cooling and heating load of all enclosures between ambient temperatures of minus 10 degrees F to 115 degrees F.

f. Heating calculations shall be done utilizing operating-load (partial load) condition of the equipment housed within the control panel. No solar load shall be used for this calculation. Furnish a detailed spreadsheet of each component housed within the enclosure and indicate its operating-load condition (in Watts), and the enclosure total internal heat load.

g. Cooling calculations shall be done utilizing full-load condition of the equipment housed within the control panel and taking into account the solar load. Furnish a detailed spreadsheet of each component housed within the enclosure and indicate its full-load condition (in Watts), and the enclosure total internal heat load.

h. If a solar shield is used to protect a panel, assume that it reduces panel solar radiation by no more than 50 percent.

i. Furnish the equations used in the heating and cooling calculations.

5. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding; label each terminal for permanent identification of leads; identify each wire at each end with imprinted mylar adhesive-back wire markers; incorporate in as-installed wiring diagrams for wire and terminal numbers shown; wiring across door hinges use 19-strand, NEMA WC-57 Class C stranding looped for proper twist rather than bending at hinge; wire connections internal to panels by crimp-on terminal types. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring; multipoint plug receptacles for any control wiring crossing equipment shipping splits.

6. Selector switches, indicating lights, potentiometers, instruments, protective devices, major system components, etc., identified by means of mechanically attached, engraved, laminated nameplates.

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F. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.

2.04 POWER SUPPLIES

A. Furnish redundant power supplies and an active redundancy module to power devices as shown on Drawings (if required).

B. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.

C. Provide output over voltage and over current protective devices.

D. Protect instruments from damage due to power supply failure.

E. Protect power supply from damage due to external failure.

F. Enclosures: NEMA 1 in accordance with NEMA 250.

G. Mount such that dissipated heat does not adversely affect other components.

H. Fuses: For each dc supply line to each individual two-wire transmitter.

1. Type: Indicating.
2. Mount so fuses can be easily seen and replaced.
3. Furnish redundant 120V ac to dc power supplies with an active redundancy module.

I. Manufacturer: Phoenix Contact Quint Series with active redundancy module.

2.05 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
   a. Interior: One coat white enamel.
   b. Exterior: One coat manufacturer’s standard gray enamel or TIA/EIA 359-1, No. 61.

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2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all drive assemblies actually furnished.

C. Record test data for report.

D. Functional Test: Perform manufacturer's standard.

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test: Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation, shall not develop amplitudes of vibration exceeding limits recommended by current edition of Hydraulic Institute Standards. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

B. Performance Test:

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 6-hour period without malfunction.
4. Demonstrate performance by operating the continuous period while varying the application load, as the input conditions allow, to verify system performance.
5. Record test data for report.

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6. With plant load connected to normal utility source, measure the following to show parameters within specified limits:
   a. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.

C. Test Equipment:

1. Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.
2. Provide diagnostic plug-in test card complete with instructions, multiposition selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

3.03 MANUFACTURERS' SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1/2 person-day for installation assistance and inspection.
   b. 1/2 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1/2 person-day for prestartup classroom or Site training.
   d. 1/2 person-day for facility startup.

END OF SECTION

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