**COLLIER COUNTY**
**NAPLES, FLORIDA**

# NCRWTP FLOW METER REPLACEMENT, SCRWTP FLOW METER AND LIME SLAKER REPLACEMENT

**CLIENT PROJECT NO. 70136.2.3, 70136.1.7, 70136.1.9**

**CONTRACT & TECHNICAL SPECIFICATIONS**

**BID SET**

**VOLUME 1 OF 1**

**MARCH 2024**

301 NORTH CATTLEMEN ROAD, SUITE 302 • SARASOTA, FLORIDA 34232 • P 941-371-9832

**COLLIER COUNTY**
**NAPLES, FLORIDA**

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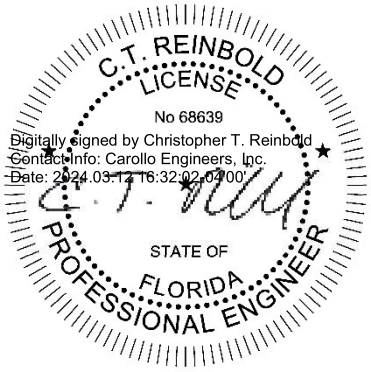
**BID SET**

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**COLLIER COUNTY**

**NCRWTP FLOW METER REPLACEMENT,**
**SCRWTP FLOW METER AND LIME SLAKER REPLACEMENT**

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# SECTION 01_11_00

# SUMMARY OF WORK

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Detailed description of the Work.

### 1.02 THE WORK

A. The Work consists of demolition and construction of the following items. All of which shall be constructed in accordance with the Drawings and Specifications:
   1. Demolish and dispose of two (2) existing lime slaking systems.
   2. Demolish and dispose of one (1) existing flow meter and associated pipes and appurtenances at the NCRWTP.
   3. Demolish and dispose of three (3) existing flow meters and associated pipes and appurtenances at the SCRWTP.
   4. Provide and install two (2) new lime slaking systems.
   5. Provide and install one (1) new flow meter, couplings, piping, and associated appurtenances at the NCRWTP.
   6. Provide and install three (3) new flow meters, couplings, piping, and associated appurtenances at the SCRWTP.

B. The work to be performed under this Contract shall consist of furnishing all tools, equipment, materials, supplies, and manufactured articles and for furnishing all transportation and services, including fuel, power, water, and essential communications, and for the performance of all labor, work, or other operations required for the fulfillment of the Contract in strict accordance with the Contract Documents.

C. Implied and Normally Required Work: It is the intent of these Specifications to provide the County with complete operable systems, subsystems, and other items of Work. Any part or item of Work, which is reasonably implied or normally required to make each installation satisfactorily and completely operable, is deemed to be included in the Work and the Contract Amount. All miscellaneous appurtenances and other items of Work incidental to meeting the intent of these Specifications are included in the Work and the Contract Amount even though these appurtenances may not be specifically called for in these Specifications.

D. Quality of Work: Regard the apparent silence of the Contract Documents as to any detail, or the apparent omission from them of a detailed description concerning any Work to be done and materials to be furnished as meaning that only the best general practice is to prevail and that only materials and workmanship of the best quality are to be used. Interpretation of these specifications will be made upon this basis.

E. Except as specifically noted otherwise, provide and pay for:
   1. Insurance and bonds.
   2. Labor, materials, and equipment.
   3. Tools, equipment, and machinery required for construction.
   4. Utilities required for construction.
   5. Temporary facilities including sheeting and shoring.
   6. Traffic control and dust control measures.
   7. Other facilities and services necessary for proper execution and completion of the Work.

## 1.03 LOCATION OF PROJECT

A. The Work is located at the following locations:

   1. North County Regional Water Treatment Plant (NCRWTP) located at 8005 Vanderbilt Beach Rd, Naples, FL 34120.

   2. South County Regional Water Treatment Plant (SCRWTP) located at 3851 City Gate Boulevard near the City of Naples, Florida, 34117.

## 1.04 COUNTY ASSIGNED SUBCONTRACTORS

A. There are no County-assigned sub-contractors.

## 1.05 ACTIVITIES BY OTHERS

A. Activities by others which may affect performance of work include:
   1. County will continuously operate the NCRWTP and SCRWTP as a public water supply. As such, there will be ongoing operations and maintenance activities by either County forces or outside contracted firms. Contractor shall not interfere with the work of others in or near the work area.
   2. The County will occupy premises during the entire period of construction in order to maintain normal operations. Cooperate with the County's Manager or designee in all construction operations to minimize conflict, and to facilitate County usage.

## 1.06 QUALIFICATION OF BIDDERS

A. Minimum qualification requirements for General Contractors shall include completion of at least 3 projects in the past ten (10) years, which meet the following criteria:
   1. Minimum contract value of $1,000,000.
   2. Water or wastewater treatment plant projects. The scope of work for these reference projects shall include replacement and/or rehabilitation of an existing lime slaker system. Contractor superintendent shall have directly performed lime slaker system replacement and/or rehabilitation at water treatment facility within the last 5 years.
   3. Retrofit, rehabilitation, or improvements completed to an operating water or wastewater facility without unreasonable disruptions to service due to Contractor’s actions or failure to act.

4. Work including water retaining structures, gravity piping systems, site work, structural repair, mechanical, and work of similar type, size, and complexity.
5. Projects completed and operating to the satisfaction of County (to be verified by calling references).
6. Projects completed on time.
7. Projects completed within budget without unreasonable claims or excessive change orders.
8. Proposed project manager and superintendent shall personally have completed projects to meet all criteria listed above as well.

B. Any sub-contractors selected by Contractor shall have equivalent experience for the trade in which the work will be performed (exclusive of dollar value noted).

## 1.07 COORDINATION OF WORK

A. Contractor shall have a preconstruction video made that records the project sites (with the Engineer and County present) including all concrete and asphalt pavements, curb and gutter, fencing to remain, structures to be demolished, and existing structures and facilities that are to be modified.
1. The original and 2 copies of the DVD shall be turned over to Engineer and County prior to beginning construction activities.
2. The format of the video file on the DVD shall be 1 file that can be played on a desktop in the windows media player.
3. The video shall clearly identify existing site and structural conditions prior to construction.

## 1.08 CONTRACTOR'S USE OF SITE

A. Limit use of site and premises for work and storage to allow for the following:
1. Coordination of the Work under this Contract with the work of the other Contractors where Work under this Contract encroaches on the Work of other Contractors.
2. County occupancy and access to operate existing facilities.
3. Coordination of site use with Engineer.
4. Responsibility for protection and safekeeping of products under this Contract.
5. Providing additional off-site storage at no additional cost to the County as needed.

## 1.09 COUNTY OCCUPANCY

A. The County will occupy premises during the entire period of construction in order to maintain normal operations. Cooperate with the County’s Manager or designee in all construction operations and minimize conflict, and to facilitate County’s usage.

B. Conduct operations with the least inconvenience to the general public.

# PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01_14_00

# WORK RESTRICTIONS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Requirements for sequencing and scheduling the Work affected by existing site and facility, work restrictions, and coordination between construction operations and plant operations.

### 1.02 SUBMITTALS

A. Baseline Schedule with MOP tasks.

B. Method of Procedure (MOP) Form.

C. Method of Procedure (MOP) Log.

D. Progress Schedule with MOP tasks.

### 1.03 GENERAL CONSTRAINTS ON WORK AND SCHEDULING OF WORK

A. Perform abandoned pipe Work as specified.

B. Water projects:
   1. The North County Regional Water Treatment Plant (NCRWTP) and South County Regional Water Treatment Plant (SCRWTP) are the County's sole source of drinking water.
   2. Conduct Work such that the County's ability to meet its customer's demands for treated drinking water shall not be impaired or reduced in terms of the required quantity or quality of treated water. Do not impair the operational capabilities of essential elements of the treatment process or reduce treatment capacity below levels sufficient to meet demands for water throughout the contract time. The quantities of and quality of treated water required are described in this Section.
   3. Conduct commissioning activities as specified in Section 01_75_17 - Commissioning in a manner that will not impair capabilities of essential elements of the treatment process or reduce treatment capacity below levels sufficient to meet demands for water throughout the contract time. The quantities of and quality of treated water required are described in this Section.
   4. PCIS Optimization and Fine-Tuning as specified in Section 01_75_17 - Commissioning.
   5. The status of the treatment plant shall be defined as "operational" when the plant is capable of meeting the County's customer's demands for treated drinking water in terms of the required quantity or quality of treated water as defined in this Section.

## 1.04 COMPLIANCE WITH DRINKING WATER PERMIT

A. The existing facility is operating under the terms of a Drinking Water permit issued by the Florida Department of Environmental Protection.
   1. This permit specifies the water quality limits that the plant must meet prior to discharge of finished water.
   2. A copy of the existing permit is on file for review at the NCRWTP and SCRWTP, respectively.

B. Perform work in a manner that will not prevent the existing facility from achieving the finished water quality requirements established by regulations.

C. Bear the cost of penalties imposed on the County for water quality violations caused by actions of the Contractor.

D. Conduct the Work and provide temporary facilities required to keep the existing plant continuously operational.

E. Do not remove or demolish existing facilities required to keep the existing plant operational at the capacities specified until the existing facilities are replaced by temporary, new, or upgraded facilities or equipment.
   1. Test replacement facilities to demonstrate operational success prior to removing or demolishing existing facilities.

## 1.05 UTILITIES

A. Provide advance notice to and utilize services for location and marking of underground utilities operated by utility agencies other than the County.
   1. Sunshine State One Call, at 1-800-432-4770.
   2. Other locating service retained and paid by Contractor as required for the performance of the work.

B. Maintain electrical, telephone, water, gas, sanitary facilities, and other utilities within existing facilities in service. Provide temporary utilities when necessary.

C. New yard utilities were designed using existing facility drawings.
   1. Field verification of utilities locations was not performed during design.
   2. Services crossed or located nearby by new yard utilities may require relocation and possible shutdowns.
   3. Pipe alignments as indicated on the Drawings.

## 1.06 WORK BY OTHERS

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

## 1.07 SHUTDOWN CONSTRAINTS

A. General shutdown constraints:
   1. Execute the Work while the existing facility is in operation.
   2. Some activities may be accomplished without a shutdown.

3. Apply to activities of construction regardless of process or work area.
4. Activities that disrupt plant or utilities operations must comply with these shutdown constraints.
5. Organize work to be completed in a minimum number of shutdowns.
6. Provide thorough advanced planning, including having required equipment, materials, and labor on hand at time of shutdown.
7. Shutdown MOPs:
    a. Advise the Engineer a minimum of 3 weeks prior to need for any complete or partial plant shutdown for tie-ins.
    b. Prepare and submit MOP to Engineer for any complete or partial plant shutdown required a minimum of 2 weeks prior to the shutdown.
    c. County's written approval of MOP is required prior to beginning Work.
8. Where required to minimize treatment process interruptions while complying with specified constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.
9. Final determination of the permitting of shutdowns will be the sole judgment of the County.
10. County maintains the ability to abort on the day of the scheduled shutdown.
11. Unplanned shutdowns due to emergencies are not specified in this Section.

B. Unit process availability work limitations:
1. Shutdowns and tie-ins or other activities that disrupt plant operations are prohibited unless the following unit process availability conditions exist and unless otherwise approved in writing by the County and Engineer.
2. At a minimum, the following facilities must be in service in order to proceed with a scheduled shutdown.
    a. The reverse osmosis treatment system.
    b. Transfer pumps and blend tank.
    c. Finished water storage tanks.
    d. High service pumps.
    e. All associated chemical storage and feed system necessary to operate the reverse osmosis treatment system including subsequent disinfection.
3. A full-plant shut down will be required for the flow meter replacement work.
    a. Contractor to coordinate directly with the County and Engineer to develop an acceptable MOP for the replacement of the existing flow meters. See Section 1.09 Work Sequence for additional details.

C. Shutdown activities:
1. Scheduling:
    a. Perform between the hours as approved by County. Shutdowns shall be planned and executed by the Contractor which shall not exceed 12 hours in duration.
    b. Shutdowns shall not be allowed on Fridays or County holidays.
2. Unplanned shutdowns due to emergencies are not defined in this Section.

D. Dewatering of existing process:
    1. When the County has turned the process unit over to the Contractor for modification or temporary use, the Contractor is responsible for costs and procedures required to dewater and dispose of liquid in the process units and/or connecting piping.
        a. Drainage and disposal of process unit liquids, solids, etc. into another treatment process unit on the plant site may be allowed if approved in advance by the Engineer and County and is conducted in accordance with County's requirements.
        b. Costs for dewatering and preparation of surfaces for the Work are the Contractor's responsibility.
        c. Contractor shall provide adequate time in schedules for draining and cleanup of tanks and piping.

E. Process area construction constraints:
    1. The following constraints shall be observed while working in and around each of the following process areas.
    2. Material hauling operations:
        1) Contractor shall comply with restrictions regarding Contractor's use of site and premises as specified in Section 01_11_00 - Summary of Work.

## 1.08 WORK SEQUENCE

A. Contractor shall sequence the work to minimize disruption to the existing operation of facilities, keep plant drives accessible for personnel and fire access and chemical deliveries, and coordinate the following tasks along with all other activities required to complete the work indicated on the Drawings and Specifications:
    1. Only one of the two lime slakers may be taken out of service to perform the work, as indicated on the Drawings, at any time.
    2. Only one flowmeter may be taken out of service to perform the work, as indicated on the Drawings, at any time.
    3. All features shall be constructed up to the point of connection, but not making the connection, to existing process features.
    4. Perform installation testing, functional testing, and clean water facility testing. All work shall be deemed substantially complete such that the request for clearance to place components into service may be requested from FDEP.
    5. Upon receipt of authorization to place components into service, perform process startup.
    6. For any other item indicated in the Contract Documents, but not listed above, Contractor shall sequence construction to minimize impacts to the existing water treatment plant processes.
    7. All surfaces that come into contact with potable water, or water being treated to become potable water, or chemicals used to treat the water, shall be disinfected per Section 01_75_18.

B. Work sequence for the replacement of the flow meters and lime slaking equipment at the SCRWTP and the replacement of flow meter at the NCRWTP shall additionally include the following:
    1. The County will shut down one of the two lime slaker systems.

2. Demolition and removal of the off-line equipment shall be conducted, as described in the Drawings.
3. New lime slaking equipment shall be installed, tested, and placed into service prior to the shut down and decommissioning of the remaining existing slaker. The new equipment shall be confirmed to be operational and performing with the operational design parameters.
4. The remaining existing slaker system shall be demolished and removed. New equipment shall be installed in place of the removed equipment.
5. The County will shut down the NCRWTP, as submitted and approved in the MOP.
6. Provide new 42” Butterfly valve at NCRWTP and fully commission prior to beginning demolition of the existing NCRWTP flowmeter.
7. Demolish and remove existing NCRWTP venturi flowmeter, connections, piping, and appurtenances, as indicated in the Drawings.
8. Furnish and install new NCRWTP flowmeter as indicated in the Drawings.
9. Disinfect new installation per specification 01_75_18.
10. The County will start up NCRWTP following construction activities.
11. The County will shut down the SCRWTP piping to the identified flow meter for replacement, as submitted and approved in the MOP.
12. Demolish and remove existing SCRWTP venturi flowmeter (or magnetic flowmeter), connections, piping, and appurtenances, as indicated in the Drawings.
13. Furnish and install new SCRWTP flowmeter as indicated in the Drawings.
14. The County will start up SCRWTP following construction activities.
15.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## ATTACHMENT A - METHOD OF PROCEDURE (MOP)

## "METHOD OF PROCEDURE" (MOP)
## Instructions and Forms

### Definition and Purpose

"Method of Procedure" (MOP) is a detailed document submitted by the Contractor to request process shutdown(s), utility tie-in(s), work in areas that may risk unanticipated outages, or flow diversions to accommodate site construction activities during a project. Such activities may include (but are not limited to) new tie-ins to utilities or structures, mechanical modifications to process piping or equipment, demolition, bulkhead installation, and cleaning processes.

The MOP provides a detailed plan to the County and Engineer that describes specific aspects of the work including purpose, time of execution, and anticipated impacts on treatment processes. The MOP also includes contingency measures and provisions for rapid closure in the event that shutdown or work progress difficulties are encountered. Information from relevant trades associated with the requested shutdown, diversion, or tie-in is also included.

The County should use the information within the MOP to define operational procedures and methods to safely and successfully assist the Contractor.

### MOP Process Summary

| WHO | STEP | TIMING |
|---|---|---|
| Contractor | 1. Identify MOPs needed on MOP Log and Baseline Schedule. | No later than 7 days prior to Preconstruction Scheduling Meeting |
| Contractor, County, Engineer | 2. Pre-MOP Meeting. | More than 28 days prior to work |
| Contractor | 3. Submits MOP. | No later than 28 days prior to work |
| County | 4. Reviews MOP. | |
| County | 5. MOP finalized. | No later than 7 days prior to work |
| Contractor | 6. Complete Readiness Checklist. | No later than 5 days prior to work |
| Contractor | 7. Complete Safety Checklist. | Immediately prior to commencing work |
| Contractor | 8. Complete Work. | |
| Contractor | 9. Update MOP Log and Progress Schedules. | Monthly |

### MOP Process Detail

STEP 1. Identifies MOPs needed on MOP Log and Baseline Schedule.

Contractor submits a preliminary list of anticipated project MOPs on MOP Log. MOPs identified but not limited to those shutdowns, diversions, or tie-ins described in the Contract Documents. Incorporate MOPs as tasks in Baseline Schedule. Date scheduled MOPs to coincide with the appropriate construction activities.

STEP 2. Pre-MOP Meeting.

Contractor requests a Pre-MOP Meeting with the County and Engineer to discuss the nature of the shutdown, diversion, or tie-in, and to gather the information necessary to complete the MOP Form. The pre-MOP meeting may be waived by the County or Engineer if the work is deemed to be minor.

STEP 3. Submits MOP.

Contractor completes the MOP Form and submits 3 copies for approval to the County's Project Manager (OPM).

STEP 4. Reviews MOP.

OPM distributes MOP Form for review by the County's Construction Coordinator, O&M Representative, and Engineer's Project Representative. Review MOP Form for completeness, accuracy, compliance with both the construction schedule, constraints defined in Contract Documents, and to ensure that the requested work does not negatively impact plant operations or other concurrent project activities. Additional information may be requested to better understand the nature of and method for completing the Work.

STEP 5. MOP finalized.

Once the MOP is agreed to by all parties, the MOP will be finalized by signature. Copies are distributed to the County, Engineer, and Contractor.

STEP 6. Complete Readiness Checklist.

Contractor verifies everything is ready for the Work.

STEP 7. Complete Safety Checklist.

Contractor ensures safety.

STEP 8. Complete Work.

Contractor completes Work.

STEP 9. Update MOP Log and Progress Schedules.

Contractor updates MOP Log weekly and distributes at the regularly scheduled construction progress meetings.

## ATTACHMENT B - METHOD OF PROCEDURE (MOP) FORM

# METHOD OF PROCEDURE (MOP) FORM

**County:** _____ **Date:** _____

**Contractor:** _____ **Carollo Project No.:** _____

**Project Name:** _____ **Submittal No.:** _____

**Submittal Title:** _____ **Spec/Drawing. Ref.:** _____

| MOP #: | TASK TITLE: *(Provide <10 word title)* | SUBMITTAL DATE: *(No later than 28 days prior to work)* |
|---|---|---|

SCHEDULE OF WORK ACTIVITY:

START: *(Date/Time)* END: *(Date/Time)*

REQUESTOR:

| PRIMARY POINT OF CONTACT: | PHONE/PAGER: |
|---|---|
| SECONDARY POINT OF CONTACT: | PHONE/PAGER: |

| NOTIFY: ☐ | Control Room, Phone: | ☐ | Security, Phone: |
|---|---|---|---|

| BUILDING: | LOCATION OF WORK FLOOR/LEVEL: |
|---|---|

DESCRIPTION OF WORK: *(Provide sufficient details on process isolation, work sequencing, and safety (i.e. control of significant hazards unique to the work) to demonstrate an understanding of the work and how it will be completed within the constraints, and its impact on the processes and facility.)*

Task Summary: _____

Processes Affected: _____

Trades Affected: _____

WORK PLAN:

Work Sequencing: _____

Process Isolation: _____

Spill Prevention Plan: _____

Contingency Plans: _____

CRITICAL EQUIPMENT / TOOLS: *(Pumps and discharge hoses with correct fittings, blind flanges and pipe plugs, no-hub fittings, properly sized electrical service components, generators, portable lighting, chlorine for potable water pipe breaks, etc.)*

| | | | | | |
|---|---|---|---|---|---|
| ☐ | Acoustic Ceiling/or Walls Access | ☐ | Excavation Permit | ☐ | Lock Out/Tag Out |
| ☐ | Chemical Use Approval | ☐ | Fire Sprinkler Impairment | ☐ | Life Safety Systems |
| ☐ | Confined Space Permit | ☐ | Flammable Materials | ☐ | Roof Protocol |
| ☐ | Critical Lift Plan | ☐ | Flush / Discharge | ☐ | Work After Dark |
| ☐ | Energized Electrical Work | ☐ | High Pressure Test | ☐ | |
| ☐ | Elect. Panel Schedules | ☐ | Hot Work/Open Flame | ☐ | |

| EXISTING SERVICE(S) AT RISK: | | | | | | | |
|---|---|---|---|---|---|---|---|
| ☐ | Breathing Air | ☐ | Elect Normal | ☐ | Process Access | ☐ | Telephones |
| ☐ | Chemical Distribution | ☐ | Fire Protection | ☐ | Safety Showers | ☐ | UPS |
| ☐ | City Water | ☐ | HVAC | ☐ | SCADA | ☐ | VAX/DATA |
| ☐ | Communication | ☐ | Inert Gas | ☐ | Security | ☐ | |
| ☐ | Domestic Drain | ☐ | Instrument - Air | ☐ | Solvent Drain | ☐ | |
| ☐ | Elect-Bus Duct | ☐ | Life Safety System | ☐ | Specialty Gases | ☐ | |
| ☐ | Elect. Emergency | ☐ | Natural Gas | ☐ | Storm Drain | ☐ | |
| REVIEWER'S INSTRUCTIONS/COMMENTS: | | | | | | | |
| ☐ | PREJOB BRIEFING MUST BE COMPLETED PRIOR TO COMMENCING WORK: | | | | | | |

| | **Full Name (printed)** | **Signature** | **Phone** | **Date** |
|---|---|---|---|---|
| Submitted By | | | | |
| System County | | | | |
| Reviewer (if needed) | | | | |
| Reviewer (if needed) | | | | |
| Reviewer (if needed) | | | | |
| Reviewer (if needed) | | | | |

## ATTACHMENT C - READINESS CHECKLIST

**READINESS CHECKLIST**

(5 days prior to work)

Checklist provided as a guide but is not all inclusive.

1. Confirm all parts and materials are on site: _____

2. Review work plan: _____

3. Review contingency plan: _____

## ATTACHMENT D - SAFETY CHECKLIST

## SAFETY CHECKLIST

(Just prior to commencing work)

Checklist provided as a guide but is not all inclusive.

1. Location awareness:
   a. Emergency exits: _____
   b. Emergency shower and eyewash: _____
   c. Telephones and phone numbers: _____
   d. Shut-off valve: _____
   e. Electrical disconnects: _____
2. Inspect work area:
   a. Take time to survey the area you are working in. Ensure that what you want to do will work. Do you have enough clearance? Is your footing secure? Do you have adequate lighting and ventilation? Are surrounding utilities out of the way for you to perform your work?
3. SDS (Safety Data Sheets):
   a. Understand the chemicals and substances in the area you are working in by reading the SDS.
4. Lockout/Tagout Procedure:
   a. Lockout/tagout energy sources before beginning work.
   b. Make sure all valves associated with the work are locked out and tagged out on each side of the penetration.
   c. Make sure the lines are depressurized.
5. Overhead work:
   a. Use appropriate personal protective equipment; i.e., safety harness, lifeline, etc.
   b. Select appropriate tie-off points; i.e., structurally adequate, not a pipe or conduit, etc.
   c. Spotter assigned and in position.
   d. Pipe rack access; i.e., check design capacity, protective decking or scaffolding in place, exposed valves or electrical switches identified and protected.
6. Safety equipment:
   a. Shepherd's hook.
   b. ARC flash protection.
   c. Fire extinguisher.
   d. Other: _____
7. Accidents:
   a. Should accidents occur, do not shut off and do not attempt to correct the situation unless you are absolutely positive that your action will correct the problem and not adversely affect other people or equipment.
8. Review process start-up documents:
   a. In the event the system is shutdown, the Control Center should have a working knowledge of the process start-up procedures in order to deal effectively with unforeseen events.
9. Evacuation procedures:
   a. Do not obstruct evacuation routes.
   b. Take time to survey the area for evacuation routes.

## ATTACHMENT E - METHOD OF PROCEDURE (MOP) LOG

## METHOD OF PROCEDURE (MOP) LOG
## Sample

| MOP Number | Task Title | Date Requested | Date Approved | Date Work Planned | Work Completed (Yes/No) |
|---|---|---|---|---|---|
| 001 | | | | | |
| 002 | | | | | |
| 003 | | | | | |

## SECTION 01_21_00

## ALLOWANCES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Listing of allowance items:
      a. Related responsibilities of Contractor and procedures.

### 1.02 ALLOWANCE AMOUNTS

A. Contract Allowance - dollar value as indicated on the schedule of bid prices.

### 1.03 COSTS INCLUDED AND EXCLUDED IN ALLOWANCES

A. Costs included in allowances for furnishing products only:
   1. Net cost of product.
   2. Delivery and unloading at site.
   3. Applicable taxes and fees.

B. Costs included in Contract Price, but not included in allowances for furnishing products only:
   1. Handling at site, including uncrating and storage.
   2. Protection from elements, theft, and damage.
   3. Labor, installation, testing, and finishing.
   4. Other expenses required to complete installation.
   5. Overhead and profit.

C. Costs included in allowances for furnishing and installing products:
   1. Net cost of product.
   2. Delivery and unloading at site.
   3. Applicable taxes.
   4. Handling at site, including uncrating and storage.
   5. Protection from elements and from damage.
   6. Labor, installation, testing, and finishing.
   7. Other expenses required to complete installation.

### 1.04 DUTIES OF CONTRACTOR IN PROVIDING PRODUCTS BY ALLOWANCE

A. Advise Engineer at least 60 days in advance of purchase date necessary to avoid impacts to Progress Schedule.

B. Obtain proposals from suppliers, including:
   1. Quantity.
   2. Complete description of product and services provided under allowance.
   3. Unit cost.

4. Total amount of purchase.
5. Taxes and delivery charges.

C. On notification of selection, enter into purchase agreement with designated supplier.

D. Arrange for delivery and unloading.

E. Install products in accordance with Contract Documents.

## 1.05 ADJUSTMENT OF COSTS

A. When actual cost is more or less than amount of allowance, Contract Price will be adjusted by Change Order.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01_29_73

# SCHEDULE OF VALUES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Requirements for preparation, format, and submittal of Schedule of Values.

### 1.02 PREPARATION

A. Schedule of Values shall be a listing of all cost loaded, on-site construction activities from the progress schedule, listed in numerical order, showing that the sum total of all cost-loaded activities equal the Contract value.

B. When the schedule is changed or revised to include added or deleted work, the Schedule of Values shall also be revised such that the sum total of all cost-loaded activities continuously equal the current Contract value.
   1. Equate the aggregate of these costs to the Lump Sum Contract Price.

A. The work shall be divided in a sufficient number of major items to outline the overall project. The Engineer may recommend adding/deleting items in submitted Schedule of Values at his discretion. Recommended division of major items of work as follows:
   1. Mobilization.
   2. Demobilization.
   3. Demolish and dispose of two (2) existing lime slaking systems.
   4. Demolish and dispose of one (1) existing flow meter and associated pipes and appurtenances at the NCRWTP.
   5. Demolish and dispose of three (3) existing flow meters and associated pipes and appurtenances at the SCRWTP.
   6. Provide and install two (2) new lime slaking systems.
   7. Provide and install one (1) new flow meters couplings, piping, and associated appurtenances at the NCRWTP.
   8. Provide and install three (3) new flow meters couplings, piping, and associated appurtenances at the SCRWTP.
   9. Disinfection.
   10. Commissioning.
   11. Record Drawings.

B. Assign prices to Major Items of Work which aggregate the Contract Price. Base prices on costs associated with scheduled activities based on the Project Schedule for each Major Item of Work.

C. When the schedule is changed or revised to include added or deleted work, the Schedule of Values shall also be revised such that the sum total of all cost-loaded activities continuously equal the current Contract value.
   1. Equate the aggregate of these costs to the Lump Sum Contract Price.

D. The scheduled value for mobilization plus demobilization shall not exceed 5 percent of the Contract Price.
   1. Partial payments for mobilization shall be made as follows as a lump sum item:

| Construction % Complete | Allowable % of Lump Sum for Mobilization |
|---|---|
| 5 | 25 |
| 10 | 50 |
| 25 | 75 |
| 100 | 100 |

## 1.03 SUBMITTALS

A. Submit Schedule of Values for the Preliminary Schedule as specified in, Section 01_32_21 - Schedules and Reports.

B. Submittal of the Schedule of Values is a condition precedent to the issuance of any payment under this Contract.

C. Submit corrected Schedule of Values within 10 days upon receipt of reviewed Schedule of Values, but no later than 10 days prior to anticipated submittal of first Application for Payment.

D. Upon request, support prices with data that will substantiate their correctness.

E. If activities are added or removed from the Progress Schedule, revise the Schedule of Values and resubmit.

## 1.04 FORMAT FOR SCHEDULE OF VALUES

A. The format for the schedule of values shall be Contractor’s standard, subject to review and acceptance by County and Engineer.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## SECTION 01_29_77

## APPLICATIONS FOR PAYMENT

### PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Procedures for preparation and submittal of Applications for Payment.

### 1.02 FORMAT

A. Develop satisfactory spreadsheet-type form generated by downloading cost data from the Progress Schedule.
   1. Submit payment requests and attach spreadsheet with cost data related to Progress Schedule.

B. Fill in information required on form.

C. When Change Orders are executed, add Change Orders at end of listing of scheduled activities:
   1. Identify change order by number and description.
   2. Provide cost of change order in appropriate column.

D. After completing, submit Application for Payment.

E. Engineer will review application for accuracy. When accurate, Engineer will transmit application to County for processing of payment.

F. Execute application with signature of responsible officer of Contractor.

### 1.03 SUBSTANTIATING DATA

A. Provide Substantiating Data identifying:
   1. Project.
   2. Application number and date.
   3. Cost flow summary.
   4. Updated schedule of values.
   5. Progress schedule.
   6. Detailed list of enclosures.
   7. Stored products log with item number and identification on application, description of specific material, and proof of insurance coverage for offsite stored products.
   8. Equipment log.
   9. Submit “certified” payroll, if applicable.
   10. Record (as-built) documents.
   11. Photos and videos from current pay period.

12. Applicable unconditional waiver and release on progress payment for previous payment made by County.

## 1.04 SUBMITTALS

A. Submit Application for Payment and Substantiating Data with cover letter.

## 1.05 PAYMENT REQUESTS

A. Prepare progress payment requests on a monthly basis. Base requests on the breakdowns of costs for each scheduled activity and the percentage of completion for each activity.

B. Indicate total dollar amount of work planned for every month of the project. Equate sum of monthly amounts to Lump Sum Contract Price.

C. Generate Progress Payment request forms by downloading cost data from the schedule information to a spreadsheet type format.

D. Identify each activity on the Progress Schedule that has a cost associated with it, the cost for each activity, the estimated percent complete for each activity, and the value of work completed for both the payment period and job to date.

E. Prepare summary of cost information for each Major Item of Work listed in the Schedule of Values. Identify the value of work completed for both the payment period and job to date.

F. Payment period:
   1. Monthly Application for Payment period shall begin on the 1st day of each month, and end on the last day of each month.
   2. Submit Application for Payment to Engineer no later than the 5th day of each month for work completed the previous month.
   3. Engineer will finalize and submit recommendation for Application for Payment to County by the 15th day of each month to allow time for processing and approval.

G. Track stored material and installed material.

H. Payment shall only be considered for work completed on-site and materials stored (which are not yet incorporated into the Work) provided that it is in full compliance with the Contract Documents.

## 1.06 COST SUMMARIES

A. Prepare Summary of Cost Information for each Major Item of Work listed in the Schedule of Values. Identify the Value of Work Completed for both the payment period and job to date.

B. Cash flow summary: Prepare cash flow summary, indicating total dollar amount of work planned for each month of the project. Equate sum of monthly amounts to Lump Sum contract price.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## SECTION 01_31_19

## PROJECT MEETINGS

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Requirements for conducting conferences and meetings for the purposes of addressing issues related to the Work, reviewing and coordinating progress of the Work and other matters of common interest, and includes the following:
      a. Qualifications of Meeting Participants.
      b. Basic Meeting Requirements.
      c. Pre-construction Conference.
      d. Progress Meetings.
      e. Pre-Installation Meetings.
      f. Commissioning Coordination Meetings.
      g. Post Construction Meeting.

## 1.02 QUALIFICATIONS OF MEETING PARTICIPANTS

A. Representatives of entities participating in meetings shall be qualified and authorized to act on behalf of entity each represents.

## 1.03 BASIC MEETING REQUIREMENTS

A. Attendees:
   1. Meeting leader shall require attendance of parties directly affecting, or affected by, Work being discussed at the meeting.

B. Location:
   1. In location convenient for most invitees.

C. Notification:
   1. Meeting leader shall notify attendees of meeting, including an agenda, a minimum of 7 days prior to meeting.

D. Agenda:
   1. Meeting leader shall prepare copies of the agenda for participants and distribute at the meeting.
   2. Minimum requirements:
      a. Meeting purpose.
      b. Review minutes of previous meeting.
      c. Safety and security.
      d. Discuss issues.
      e. Action items.
      f. Next meeting.

E. Meeting minutes:
   1. Meeting leader shall prepare draft minutes and send to attendees for comment within 14 days.
   2. Meeting leader shall incorporate comments from attendees and submit final meeting minutes to attendees within 7 days of receipt of comments.

## 1.04 PRE-CONSTRUCTION CONFERENCE

A. Engineer leads the meeting.

B. Timing:
   1. Upon issuance of Notice to Proceed, or earlier when mutually agreeable.

C. Required attendees:
   1. Contractor's project manager and superintendent, Owner, Engineer, representatives of utilities, major subcontractors and others involved in performance of the Work, and others necessary to the agenda.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. To establish working understanding between parties and to discuss Construction Schedule, Shop Drawings and other Submittals, cost breakdown of major lump sum items, processing of Submittals and applications for payment, and other subjects pertinent to execution of the Work.
   2. Adequacy of distribution of Contract Documents.
   3. Distribution and discussion of list of major subcontractors and suppliers.
   4. Proposed progress schedules and critical construction sequencing.
   5. Major equipment deliveries and priorities.
   6. Project coordination.
   7. Designation of responsible personnel.
   8. Procedures and processing of:
      a. Field decisions.
      b. Proposal requests.
      c. Submittals - separate meeting.
      d. Change Orders.
      e. Request for Information/Interpretations.
      f. Applications for Payment.
      g. Record documents.
   9. Use of premises:
      a. Office, construction, and storage areas.
      b. Owner's requirements.
   10. Construction facilities, controls, and construction aids.
   11. Temporary utilities.
   12. Safety and first aid procedures.
   13. Security procedures.
   14. Housekeeping procedures.
   15. Safety and security.
   16. Review proposed photographer Submittal.
   17. Action items.
   18. Next meeting.

## 1.05 PRE-CONSTRUCTION SCHEDULING MEETING

A. Engineer leads the meeting.

B. Timing:
   1. Within 7 days of Notice to Proceed, or earlier when mutually agreeable.

C. Required attendees:
   1. Contractor's project manager, superintendent, scheduler, Owner, Engineer, and others necessary to the agenda.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. To establish the format and features of the Construction Schedule.
   2. Schedule preparation.
   3. Reporting requirements.
   4. Updates and revision procedures.
   5. Schedule delay analysis procedures.
   6. Schedule methodology.
   7. Planned sequence of operations.
   8. Cost and labor loading methodology.
   9. Proposed activity coding structure as specified in Section 01_32_21 - Schedules and Reports.
   10. Naming convention: Name schedule files with the year, month and day of the data date, revision identifier, and a description of the schedule.
      a. Example 1: 2021_07_30 rev 1 draft baseline schedule.xer.
      b. Example 2: 2021_09_30 rev 2 sep final update.xer.
   11. Action items.
   12. Next meeting.

## 1.06 PROGRESS MEETINGS

A. Engineer will lead the meeting.

B. Timing:
   1. Hold meetings throughout progress of the Work at maximum weekly intervals.

C. Required attendees:
   1. Owner, Engineer, Contractor, Contractor's project manager, superintendent, quality control manager, project scheduler, major subcontractors and suppliers as appropriate to the agenda topics for each meeting.
   2. Additional invitees:
      a. Owner utility companies when the Work affects their interests, and others necessary to the agenda.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Provide the status of the Work.
   2. Review minutes of previous meeting.
   3. Safety and security.
   4. Construction schedule summary.

5. Review of 6 weeks schedule.
    a. Contractor shall provide printed hard copies for each attendee.
6. Review of off-site fabrication and delivery schedules.
7. Review of Submittals schedule and status of Submittals.
8. Request for information (RFI's) status.
9. MOP's/shutdown coordination.
10. Change order management status.
11. Maintenance of quality standards (QA/QC).
12. Field observations, problems, and conflicts.
13. Commissioning.
14. Partnering recognition status (optional).
15. General items.
16. Action items.
17. Next meeting.

## 1.07 PRE-INSTALLATION MEETINGS

A. Contractor leads the meeting.

B. Timing:
    1. When specified in Technical Sections or requested by Engineer, before commencing Work of specific section.

C. Required attendees:
    1. Owner, Engineer, Contractor, Contractor's project manager, general superintendent, project scheduler, major subcontractors including electrical instrumentation, and suppliers as appropriate to the agenda topics for each meeting.
    2. Additional invitees:
        a. Owner utility companies when the Work affects their interests and others necessary to the agenda.

D. Agenda minimum requirements:
    1. Meeting purpose:
        a. Review conditions of installation, preparation, and installation procedures.
        b. Review coordination with related work.
    2. Review minutes of previous meeting.
    3. Safety and security.
    4. Action items.
    5. Next meeting.

## 1.08 COMMISSIONING COORDINATION MEETINGS

A. Contractor leads the meeting.

B. Timing:
    1. Separate commissioning coordination meetings will be scheduled as required by the Engineer.

C. Required attendees:
   1. Require attendance of parties directly affecting, or affected by process start-up and testing, including Engineer, Commissioning Coordinator, specific work crews, Owner's operations, and maintenance staff.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Coordinate commissioning activities.
   2. Review minutes of previous meeting.
   3. Review Commissioning schedule.
   4. Review Owner Training schedule.
   5. Review test plans.
   6. Review accepted Construction Method of Procedure (MOP), as specified in Attachment A of Section 01_14_00 - Work Restrictions.
   7. County makes final decision for commissioning GO or NO GO.
   8. Safety and security.
   9. Action items.
   10. Next meeting.

## 1.09 POST CONSTRUCTION MEETING

A. Engineer leads the meeting.

B. Timing:
   1. About 11 months after date of Substantial Completion.

C. Location:
   1. Meet in Owner's office or other mutually agreed upon place.

D. Required attendees:
   1. Engineer, Contractor, appropriate manufacturers, and installers of major units of constructions, affected Subcontractors, and Owner's operations and maintenance staff.

E. Agenda minimum requirements:
   1. Meeting purpose:
      a. Review Project for compliance with the Contract Documents.
   2. Inspect the Work and draft list of items to be completed or corrected.
   3. Review service and maintenance contracts and take appropriate corrective action when necessary.
   4. Complete or correct defective work and may extend correction period.
   5. Safety and security.
   6. Action items.
   7. Next meeting.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01_32_21

# SCHEDULES AND REPORTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Schedules and reports.

### 1.02 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Baseline schedule: A planned and approved timetable projection that illustrates the project execution strategy, key deliverables, planned activity dates and milestones.
   2. Critical path: The longest sequence of dependent tasks in a project.
   3. Near critical path: The longest path after the critical path.
   4. Weather day: The Contractor being prevented or inhibited from performing at least 4 hours of work on the critical path due to weather conditions.

### 1.03 SCHEDULING FORMAT

A. Utilize critical path method (CPM) format.

B. Provide a cost and labor loaded Schedule.

C. Engineer approval of the format is required.

### 1.04 SCHEDULING HARDWARE AND SOFTWARE

A. Scheduling software and hardware shall be located on-site.

B. Prepare computerized schedule utilizing the most current version of Oracle Primavera P6 or Asta Powerproject.

C. Contractor and Engineer must agree on the format.

### 1.05 SCHEDULE PREPARATION

A. Preparation and submittal of Progress Schedule represents Contractor’s intention to execute the Work within specified time and constraints.

B. All costs associated with Schedule requirements are included in the Contract Price.

C. During preparation of the preliminary Progress Schedule, the Engineer will facilitate Contractor’s efforts by answering questions regarding sequencing issues, scheduling constraints, interface points, and dependency relationships.

D. Prepare Schedule utilizing precedence diagramming method (PDM).

E. Prepare Schedule utilizing activity durations in terms of working days.
   1. Do not exceed a 15 working day duration on activities except concrete curing, submittal review, and equipment fabrication and deliveries.
   2. Where duration of continuous work exceeds 15 working days, subdivide activities by location, stationing, or other sub-element of the Work.
   3. Coordinate holidays to be observed with the County and incorporate them into the Schedule as non-working days.

F. Failure to include an activity required for execution of the Work does not excuse Contractor from completing the Work and portions thereof within specified times and at price specified in Contract.
   1. Contract requirements are not waived by failure of Contractor to include required Schedule constraints, sequences, or milestones in Schedule.
   2. Contract requirements are not waived by County's acceptance of the Schedule. In the event of conflict between accepted Schedule and Contract requirements, terms of Contract govern at all times, unless requirements are waived in writing by the County.

G. Reference Schedule to working days beginning with Notice to Proceed as Contract Time as Day "1".

H. Baseline Schedule and project completion:
   1. Should Contractor submit a Baseline Schedule showing project completion more than 20 working days prior to Contract completion date, County may issue Change Order, at no cost to County, revising time of performance of Work and Contract completion date to match Contractor's Schedule completion date.
   2. Adjust accordingly any Contract milestone dates.

I. Imposed dates and hidden logic are prohibited.

J. Interim milestone dates, operational constraints:
   1. In event there are interim milestone dates and/or operational constraints set forth in Contract, show them on Schedule.
   2. Do not use zero total float constraint or mandatory finish date on such Contract requirements.

K. Contract float is for the mutual benefit of both County and Contractor.
   1. Changes to the Project that can be accomplished within this available period of float may be made by County without extending the Contract Time by utilizing float.
   2. Time extensions will not be granted nor delay damages owed until Work extends beyond currently accepted Contract completion date.
   3. Likewise, Contractor may utilize float to offset delays other than delays caused by the County.

4. Mutual use of float can continue until all available float shown by Schedule has been utilized by either County or Contractor, or both. At that time, extensions of the Contract Time will be granted by County for valid County-caused or third party-caused delays which affect the planned completion date and which have been properly documented and demonstrated by Contractor.
5. Non-sequestering of float: Pursuant to float sharing requirements of Contract, Schedule submittals can be rejected for use of float suppression techniques such as preferential sequencing or logic, special lead or lag logic restraints, extended activity durations, or imposed dates.

L. Resource loading and leveling:
1. Input labor data on each schedule activity.
2. Manpower data consists of the man-hours estimated to perform each task, categorized by trade.
3. Provide leveled manpower requirements.
a. Availability of the resources drive activity duration.

M. Cost loading: All schedules:
1. Only on-site construction activities.
2. The sum total of all cost loaded activities equal to the current value of the Contract, including change orders, at all times.
3. County acceptance of the Baseline Schedule creates the Schedule of Values required as specified in Section 01_29_73 - Schedule of Values.
4. Provide updated Schedule of Values as the monthly Payment Application as specified in Section 01_29_77 - Applications for Payment.
5. Payments will not be made until the updated Schedule of Values is accepted.

N. Schedule logic:
1. Assembled to show order in which Contractor proposes to carry out Work, indicate restrictions of access, availability of Work areas, and availability and use of manpower, materials, and equipment.
2. Form basis for assembly of schedule logic on the following criteria:
a. Which activities must be completed before subsequent activities can be started?
b. Which activities can be performed concurrently?
c. Which activities must be started immediately following completed activities?
d. What major facility, equipment, or manpower restrictions are required for sequencing these activities?

O. Schedule windows for County-furnished, Contractor-installed equipment or materials:
1. Immediately after Award of Contract, obtain from Engineer anticipated delivery dates of County furnished equipment or materials.
2. Show these dates in the Schedule in same manner indicated by the Engineer.

## 1.06 SCHEDULER

A. Designate, in writing within 5 calendar days after Notice of Award, the person responsible for preparation, maintenance, updating, and revision of all schedules.

B. Scheduler shall have the authority to update Schedule on behalf of the Contractor.

C. Qualifications:
   1. A minimum of 5 years verifiable experience in preparation of construction schedules for projects of similar value, size, and complexity.
   2. Knowledge of critical path method (CPM) scheduling utilizing the specified software.

D. County reserves the right to disapprove scheduler when submitted by Contractor if not qualified. County reserves the right to remove scheduler from the project if found to be incompetent.

## 1.07 SUBMITTAL REQUIREMENTS

A. Preliminary and Baseline Progress Schedule.

B. Preliminary and Baseline Schedule of Values.

C. Preliminary and Baseline Schedule of Submittals.

D. On a monthly basis, updated Schedules as specified.

E. Final Schedules update as specified.

F. Revised Schedules and time impact analyses as specified.

G. Submit Schedules in the media and number of copies as follows:
   1. PDF format and in other formats specified in this Section.
   2. 2 sets of CPM Schedule data electronic files in a native backed-up file format.

## 1.08 GANTT CHART

A. Produce a clear, legible, and accurate calendar based, time scaled, and graphical network diagram.
   1. Group activities related to the same physical areas of the Work. Produce the network diagram based upon the early start of all activities.

B. Include for each activity, the description, activity number, estimated duration in working days, total float, and all activity relationship lines.

C. Illustrate order and interdependence of activities and sequence in which Work is planned to be accomplished.
   1. Incorporate the basic concept of the precedence diagram network method to show how the start of 1 activity is dependent upon the start or completion of preceding activities and its completion restricts the start of following activities.

D. Provide Progress Schedule showing the critical path for the Project.

E. Provide report of Near Critical Path activities for the Project, when required by the Engineer.

F. Delineate the specified Contract Times and identify the planned completion of the Work as a milestone.
   1. Show the time period between the planned and Contract completion dates, if any, as an activity identified as Project float.

G. Identify system shutdown dates, system tie-in dates, specified interim completion or milestone dates and contract completion dates as milestones.

H. Include, in addition to construction activities:
   1. Submission dates and review periods for major equipment submittals, shoring submittals, and indicator pile program:
      a. Shoring reviews: Allow 4-week review period for each shoring submittal.
      b. Pile indicator program: Allow 3-week review period for analysis of program.
   2. Any activity by the County or the Engineer that may affect progress or required completion dates.
   3. Equipment and long-lead material deliveries over 8 weeks.
   4. Approvals required by regulatory agencies or other third parties.

I. Produce electronic network diagram on 22-inch by 34-inch sheets with grid coordinate system on the border of all sheets utilizing alpha and numeric designations.

## 1.09 PRELIMINARY SCHEDULE

A. Procedure:
   1. Submit proposed Preliminary Schedule within 14 calendar days after Notice to Proceed.
   2. Meet with Engineer within 7 calendar days after receipt of Preliminary Schedule to review and make necessary adjustments.
   3. Submit revised Preliminary Schedule within 5 calendar days after meeting.
   4. Update Preliminary Schedule monthly until the Baseline Schedule is accepted.

B. Format:
   1. Simplified Gannt chart.

C. Activities:
   1. Define activities to be completed in the first 90 calendar days of Work.
   2. Actualize activities performed during the first 90 days into the first monthly Schedule update.

## 1.10 PRELIMINARY SCHEDULE OF VALUES

A. Preliminary Schedule of Values as specified in Section 01_29_73 - Schedule of Values.

B. Procedure:
   1. Submit proposed Preliminary Schedule of Values within 14 calendar days after Notice to Proceed.
   2. Meet with Engineer within 7 calendar days after receipt of Preliminary Schedule of Values to review and make necessary adjustments.

3. Submit revised Preliminary Schedule of Values within 5 calendar days after meeting.

## 1.11 WORK WITHIN THE FIRST 90 DAYS

A. Proceed with Work after Preliminary Schedule and Preliminary Schedule of Values have been accepted by County.

B. Submittal and acceptance of Preliminary Schedule and Preliminary Schedule of Values is condition precedent to making of progress payments as specified in Section 01_29_77 - Applications for Payment and payments for mobilization costs otherwise provided for in the Contract.

## 1.12 SCHEDULE OF SUBMITTALS

A. Schedule of Submittals shall include Submittals required in the Contract Documents but not limited to test plans, training plans, test procedures, operation and maintenance manuals, Shop Drawings, samples, record documents, and specifically required certificates, warranties, and service agreements.

B. Preliminary Schedule of Submittals:
   1. Due date: After Preliminary Schedule has been submitted and accepted by the County.
   2. Format:
      a. Include Submittals anticipated in the first 90 calendar days after award of Contract using early start dates.
      b. Indicate week and month anticipated for submittal to Engineer.
      c. Indicate “Priority” Submittals where review time can impact Contractor’s schedule.
         1) “Priority” indication will not alter review times specified in Section 01_33_00 - Submittal Procedures.
         2) Engineer will endeavor to provide early review of “Priority” Submittals where possible.
   3. Submittal of Preliminary Schedule of Submittals shall be a condition precedent to County making progress payments during the first 90 calendar days after award of Contract.

C. Final Schedule of Submittals:
   1. Due date: 30 days after Baseline Schedule has been submitted and accepted by County.
   2. Format:
      a. Include Submittals using early start dates.
      b. Include all Submittals, including those required in the Preliminary Schedule of Submittals.
      c. Indicate week and month anticipated for submittal to Engineer.
      d. Indicate “Priority” submittals where review time can impact Contractor’s schedule.
         1) “Priority” indication will not alter review times specified in Section 01_33_00 - Submittal Procedures.
         2) Engineer will endeavor to provide early review of “Priority” Submittals where possible.

3. Submittal of final Schedule of Submittals shall be a condition precedent to County making progress payments after the first 90 calendar days after Notice to Proceed.

D. Provide updated Schedule of Submittals with updated schedules if Schedule revisions change listing and timing of Submittals.

## 1.13 BASELINE PROGRESS SCHEDULE AND BASELINE SCHEDULE OF VALUES

A. Due date: No more than 45 calendar days after Notice to Proceed.

B. Format:
   1. Progress Schedule: Show sequence and interdependence of all activities required for complete performance of all Work, beginning with date of Notice to Proceed and concluding with date of final completion of Contract.
   2. Schedule of Values: As specified in Section 01_29_73 - Schedule of Values.

C. Acceptance of the Baseline Progress Schedule and Baseline Schedule of Values by the County is a condition precedent to making payments as specified in Section 01_29_77 - Applications for Payment after the first 90 calendar days after Notice to Proceed.

## 1.14 SUMMARY SCHEDULE

A. Due date: At weekly progress meetings and after each Schedule update or Schedule revision.

B. Format:
   1. Consolidate groups of activities associated with Major Items of Work shown on Baseline Schedule.
   2. Intended to give an overall indication of the Project Schedule without a large amount of detail.

## 1.15 COST FLOW SUMMARY

A. Due date: After Baseline Schedule has been submitted and accepted by the County, submit on a monthly basis as specified in Section 01_29_77 - Applications for Payment.

B. Format:
   1. Tabular and graphic report showing anticipated earnings each month of the Contract period.
   2. Base tabulation on the summation of the cost-loaded activities each month.
   3. Show planned amounts.
   4. Show actual earned amounts and anticipated remaining earnings.
   5. Spreadsheet format of all schedule activities showing cost and percentage completion during the current month for which payment is sought.

## 1.16 PROGRESS SCHEDULE AND UPDATED SCHEDULE OF VALUES

A. Due date: Submit on a monthly basis as specified in Section 01_29_77 - Applications for Payment.

B. Format: As specified in Section 01_29_73 - Schedule of Values.

## 1.17 WEEKLY SCHEDULE

A. Due date: At every weekly progress meeting.

B. Format:
   1. Contractor and Engineer must agree on the format.
   2. 6-week Schedule showing the activities completed during the previous week and the Contractor's schedule of activities for following 5 weeks.
   3. Use the logic and conform to the status of the current Progress Schedule when producing a weekly Schedule in CPM schedule or a bar chart format.
      a. In the event that the weekly Schedule no longer conforms to the current Schedule, Contractor may be required to revise the Schedule as specified in this Section.
   4. Activity designations used in the weekly Schedule must be consistent with those used in the Baseline Schedule and the monthly Schedule updates.

## 1.18 LABOR HISTOGRAM

A. Due date:
   1. With progress payments after Baseline Schedule has been submitted and accepted by County.

B. Format:
   1. Labor histogram depicting total craft manpower and craft manpower for Contractor's own labor forces and those of each subcontractor.
   2. Submit in electronic format.

## 1.19 EQUIPMENT SCHEDULE

A. Due date: With any progress payment after Baseline Schedule has been submitted and accepted by County if it includes payment for equipment.

B. Format:
   1. Tabular report listing each major piece of construction equipment to be used in performing the Work.
   2. Include major equipment for Contractor and each subcontractor.
   3. Submit electronically in Excel format with 1 paper copy.

C. Progress payments after the first 90 calendar days after Notice to Proceed will not be made until equipment schedule is provided.

## 1.20 COMMISSIONING SCHEDULE

A. Commissioning activities and milestones, as specified in Section 01_75_17 - Commissioning, shall be an integral part of the overall Progress Schedule.
   1. Commissioning activities and milestones shall be extracted from the Progress Schedule to provide a separate Commissioning schedule that is submitted each time the Progress Schedule is submitted.

B. Proposed Commissioning Schedule:
   1. Schedule requirements: As specified in Section 01_75_17 - Commissioning.
   2. Engineer response due within 20 calendar days of receipt.
   3. Contractor responsible for updating schedule and resubmitting within 10 calendar days of receipt of Engineer and County comments.

C. Construction Schedule can include the Commissioning Schedule after Engineer acceptance of the Proposed Commissioning Schedule.
   1. Capable of extracting a stand-alone Commissioning Schedule.
   2. Capable of extracting a stand-alone County Training Schedule.

D. Monthly update requirements:
   1. Highlight percentages of completion, actual start and finish dates, and remaining durations, as applicable.
   2. Include activities not previously included in the previously accepted detail work plan Commissioning Schedule.
   3. Change Order required for any change to contractual dates.
   4. Reviews of these Submittals by Engineer will not be construed to constitute acceptance within the time frames, durations, or sequence of work for each added activity.

## 1.21 PRE-CONSTRUCTION SCHEDULING MEETING

A. As specified in Section 01_31_19 - Project Meetings.

## 1.22 REVIEW AND ACCEPTANCE OF SCHEDULES

A. Engineer will review preliminary Schedules, Schedule updates, Schedule revisions, and time impact analyses to ascertain compliance with specified project constraints, compliance with milestone dates, durations and sequence, accurate inter-relationships, and completeness.

B. Engineer and County will issue written comments following completion of review of baseline Schedules within 21 calendar days after receipt.

C. Written comments on review of Schedule updates and Schedule revisions and time impact analyses will be returned to Contractor within 14 calendar days after receipt by Engineer.

D. Revise and resubmit Schedules in accordance with Engineer’s comments within 7 calendar days after receipt of such comments or request joint meeting to resolve objections.

E. If the Engineer requests a meeting, the Contractor and all major subcontractors shall participate.
   1. Revise and resubmit Schedule within 7 calendar days after meeting.

F. Use accepted Schedules for planning, organizing, and directing the Work and for reporting progress.

G. Engineer's Submittal review response:
   1. When Schedules reflects the County's and Contractor's agreement of project approach and sequence, Schedules will be accepted by the County.
   2. Engineer's Submittal review response for Schedule Submittals will be "Receipt Acknowledged - Filed for Record".
   3. Acceptance of the Schedules by the County is for general conformance with the Contract Documents and for the County's planning information and does not relieve the Contractor of sole responsibility for planning, coordinating, and executing the Work within the Contract completion dates.
      a. Omissions and errors in the accepted Schedules shall not excuse performance less than that required by the Contract Documents.
      b. Acceptance by the County in no way constitutes an evaluation or validation of the Contractor's plan, sequence or means, methods, and techniques of construction.

## 1.23 SCHEDULE UPDATES

A. Any update:
   1. Prepare update using most recent accepted version of Schedule including:
      a. Actual start dates of activities that have been started.
      b. Actual finish dates of activities that have been completed.
      c. Percentage of completion of activities that have been started but not finished.
      d. Actual dates on which milestones were achieved.
      e. Update activities by inputting percent complete figures with actual dates.
      f. Use retained logic in preparing Schedule updates.
      g. When necessary, input remaining durations for activities whose finish dates cannot be calculated accurately with a percent complete figure only.
      h. Revisions to the Schedule may be included that have been previously approved as specified.

B. Monthly updates:
   1. Submit written narrative report in conjunction with each Schedule update, including descriptions of the following:
      a. Activities added to or deleted from the Schedule are to adhere to cost and other resource loading requirements.
         1) Identify added activities in manner distinctly different from original activity designations.
      b. Changes in sequence or estimated duration of activities.
      c. Current or anticipated problems and delays affecting progress, impact of these problems and delays and measures taken to mitigate impact.
      d. Assumptions made and activities affected by incorporating change order work into the Schedule.

e. Include a response in writing to each of the Engineer's comments or questions from the previous month's schedule review and number responses consistent with the Engineer's numbering.

2. Submit updated Schedule and materials specified under Submittal of Progress Schedules 5 calendar days before the monthly schedule update meeting.
3. Since monthly Schedule update is the application for progress payment required as specified in Section 01_29_77 - Applications for Payment, submittal and acceptance of the monthly Schedule update is a condition precedent to the making of any progress payments.

C. Weekly progress meeting:
1. Update the Schedule prior to weekly progress meeting.
   a. Identify overall progress of each major item of work in the summary schedule.
   b. If there are significant changes to the Schedule, submit a written report at the weekly progress meeting.
2. Should monthly Schedule update show project completion earlier than current Contract completion date, show early completion time as schedule activity, identified as "Project Float".
3. Should monthly Schedule update show Project completion later than current Contract completion date, prepare and submit a Schedule revision.

## 1.24 REVISIONS TO SCHEDULES

A. Submit revised Schedules within 5 days:
1. When delay in completion of any activity or group of activities indicates an overrun of the Contract Time or milestone dates by 20 working days or 5 percent of the remaining duration, whichever is less.
2. When delays in Submittals, deliveries, or work stoppages are encountered making necessary the replanning or rescheduling of activities.
3. When the Schedule does not represent the actual progress of activities.
4. When any change to the sequence of activities, the completion date for major portions of the Work, or when changes occur which affect the critical path.
5. When Contract modification necessitates Schedule revision, submit schedule analysis of Change Order work with cost proposal.

B. Create a separate Submittal for Schedule revisions.
1. Comply with Schedule updates as specified in this Section.
2. Do not submit with Schedule updates.

C. Schedule revisions will not be reflected in the Schedule until after the revision is accepted by the County.
1. This includes Schedule revisions submitted for the purpose of mitigating a Contractor-caused project delay (Recovery Schedule).

## 1.25 ADJUSTMENT OF CONTRACT TIME OR PRICE

A. Contract Time will be adjusted only for causes specified in Contract Documents.

B. If the Contractor believes that the County has impacted its work such that the Project completion date will be delayed, the Contractor must submit proof, in the form of a time impact analysis demonstrating the delay to the critical path.

C. Time impact analysis:
   1. Use the accepted Schedule update that is current relative to the time frame of the delay event (change order, third party delay, or other County-caused delay). Represent the delay event in the Schedule by:
      a. Inserting new activities associated with the delay event into the Schedule.
      b. Revising activity logic.
      c. Revising activity durations.
   2. If the Progress Schedule's critical path and completion date are impacted as a result of adding this delay event to the Progress Schedule, a time extension equal to the magnitude of the impact may be warranted.
   3. The time impact analysis Submittal must include the following information:
      a. A fragment of the portion of the Schedule affected by the delay event.
      b. A narrative explanation of the delay issue and how it impacted the Schedule.
      c. A schedule file used to perform the time impact analysis.

D. When a delay to the Project as a whole can be avoided by revising preferential sequencing or logic and the Contractor chooses not to implement the revisions, the Contractor will be entitled to a time extension and no compensation for extended overhead.

E. Indicate clearly that the Contractor has used, in full, all project float available for the Work involved in the request, including any float that may exist between the Contractor's planned completion date and the Contract completion date.
   1. Utilize the latest version of the Schedule update accepted at the time of the alleged delay, and all other relevant information, to determine the adjustment of the Contract Time.

F. Adjustment of the Contract Times will be granted only when the Contract float has been fully utilized and only when the revised date of completion of the Work has been pushed beyond the Contract completion date.
   1. Adjustment of the Contract Times will be made only for the number of days that the planned completion of the work has been extended.

G. Actual delays in activities which do not affect the Critical Path Work or which do not move the Contractor's planned completion date beyond the Contract completion date will not be the basis for an adjustment to the Contract Time.

H. If completion of the project occurs within the specified Contract Time, the Contractor is not entitled to job-site or home office overhead beyond the Contractor's originally planned occupancy of the site.

I. Notify Engineer of a request for Contract Time adjustment.
   1. Submit request as specified in the Contract Documents.

2. In cases where the Contractor does not submit a request for Contract Time adjustment for a specific change order, delay, or Contractor request within the specified period of time, then it is mutually agreed that the particular change order, delay, or Contractor request has no time impact on the Contract completion date and no time extension is required.

J. Engineer will, within 30 calendar days after receipt of a Contract Time adjustment, request any supporting evidence, review the facts, and advise the Contractor in writing.
   1. Include the new Progress Schedule data, if accepted by the County, in the next monthly Schedule update.
   2. When the County has not yet made a final determination as to the adjustment of the Contract Time, and the parties are unable to agree as to the amount of the adjustment to be reflected in the Progress Schedule, reflect that amount of time adjustment in the Progress Schedule as the Engineer may accept as appropriate for such interim purpose.
   3. It is understood and agreed that any such interim acceptance by the Engineer shall not be binding and shall be made only for the purpose of continuing to schedule the Work, until such time as a final determination as to any adjustment of the Contract Time acceptable to the Engineer has been made.
   4. Revise the Progress Schedule prepared thereafter in accordance with the final decision.

## 1.26 WEATHER DAY ALLOWANCE

A. Allowance:
   1. Include as a separate identifiable activity on the critical path, an activity labeled “Weather Day Allowance”.

B. Actual Weather Day:
   1. Insert a weather delay activity in the critical path to reflect actual weather day occurrences when weather days are experienced and accepted by the Engineer.
   2. Reduce duration of Weather Day Allowance activity as weather delays are experienced and inserted into the Schedule. Remaining weather days in the Weather Day Allowance at completion of the Project is considered float.
   3. Provide a written notice to the Engineer of the occurrence of a weather day within 2 days after the onset of such weather and describe in reasonable detail the type of weather encountered and the Work interfered with or interrupted.
      a. A Schedule update will not suffice as a written notice.
      b. Engineer will determine if the Weather Day constitutes a use of a portion of the Weather Day Allowance.
      c. After use of all the Weather Day Allowance, the Engineer will determine if the Contractor is entitled to an extension of the Contract Time due to weather conditions.

## 1.27 FINAL SCHEDULE

A. The final Schedule update becomes the As-Built Schedule.
   1. The As-Built Schedule reflects the exact manner in which the project was constructed by reflecting actual start and completion dates for all activities accomplished on the project.
   2. Contractor's Project Manager and scheduler sign and certify the As-Built Schedule as being an accurate record of the way the project was actually constructed.

B. Retainage will not be released until final Schedule update is provided.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01_33_00

# SUBMITTAL PROCEDURES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Requirements and procedures for Submittals to confirm compliance with Contract Documents.

### 1.02 DEFINITIONS

A. Certificates: Describe certificates that document affirmations by the Contractor or other entity that the work is in accordance with the Contract Documents.

B. Extra stock materials: Describe extra stock materials to be provided for the County's use in facility operation and maintenance.

C. Maintenance material submittals: Use this article to categorize maintenance materials submittals requiring no Engineer action other than confirmation of receipt under an explanatory heading.

D. Manufacturer's instructions: Instructions, stipulations, directions, and recommendations issued in printed form by the manufacturer of a product addressing handling, installation, erection, and application of the product; manufacturer's instructions are not prepared especially for the Work.

E. Product data: Product data usually consists of manufacturers' printed data sheets or catalog pages illustrating the products to be incorporated into the project.

F. Samples: Samples are full-size actual products intended to illustrate the products to be incorporated into the project. Sample submittals are often necessary for such characteristics as colors, textures, and other appearance issues.

G. Spare parts: Describe spare parts necessary for the County's use in facility operation and maintenance; identify the type and quantity here, but include the actual characteristics of the spare parts in Product as part of the specification of the product.

H. Shop drawings: Shop drawings are prepared specifically for the project to illustrate details, dimensions, and other data necessary for satisfactory fabrication or construction that are not shown in the contract documents. Shop drawings could include graphic line-type drawings, single-line diagrams, or schedules and lists of products and their application.

I. Submittals: Submittals are samples, product data, shop drawings, and others that demonstrate how Contractor intends to conform with the Contract Documents.

J. Tools: Tools are generally defined as items such as special wrenches, gauges, circuit setters, and other similar devices required for the proper operation or maintenance of a system that would not normally be in the County's tool kit.

## 1.03 GENERAL INSTRUCTIONS

A. Contractor is responsible to determine and verify field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and check and coordinate each item with other applicable approved Shop Drawings and Contract Document requirements.

B. Provide Submittals:
   1. That are specified or reasonably required for construction, operation, and maintenance of the Work.
   2. That demonstrate compliance with the Contract Documents.

C. Where multiple Submittals are required, provide a separate Submittal for each Specification section.
   1. In order to expedite construction, the Contractor may make more than one Submittal per Specification section, but a single Submittal may not cover more than one Specification section:
      a. The only exception to this requirement is when one Specification section covers the requirements for a component of equipment specified in another section.
      b. For example, circuit breakers are a component of switchgear. The switchgear Submittal must also contain data for the associated circuit breakers, even though they are covered in a different Specification section.

D. Prepare Submittals in the English language. Do not include information in other languages.

E. Present measurements in customary American units (feet, inches, pounds, etc.).

F. Must be clear and legible, and of sufficient size for presentation of information.

G. Page size, other than drawings:
   1. Minimum: 8 1/2 inches by 11 inches.
   2. Maximum: 11 inches by 17 inches.

H. Drawing sheet size:
   1. Maximum: 22 inches by 34 inches.
      a. Minimum plan scale: 1/8 inch equals 1 foot-0 inches.
      b. Minimum font size: 1/8-inch.
   2. 11-inch by 17-inch sheet:
      a. Minimum plan scale: 1/8 inch equals 1 foot-0 inches.
      b. Minimum font size: 1/8-inch.

I. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.

J. Provide Submittal information from only one manufacturer for a specified product. Submittals with multiple manufacturers for one product will be rejected without review.

## 1.04 SUBMITTAL ORGANIZATION

A. Organize Submittals in exactly the same order as the items are referenced, listed, and/or organized in the Specification section.

B. For Submittals that cover multiple devices used in different areas under the same Specification section, the Submittal for the individual devices must list the area where the device is used.

C. Bookmarks:
   1. Bookmarks shall match the table of contents.
   2. Bookmark each section (tab) and heading.
   3. Drawings: Bookmark at a minimum, each discipline, area designation, or appropriate division.
   4. At file opening, display all levels of bookmarks as expanded.

D. Where applicable (i.e., except for Drawings, figures, etc.), Submittal content shall be electronically searchable utilizing the PDF file as submitted.

E. Thumbnails optimized for fast web viewing.

F. Sequentially number pages within the tabbed sections:
   1. Submittals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

G. Attachments:
   1. Include with each Submittal a copy of the relevant Specification section.
      a. Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (√) or deviation with a consecutive number (1, 2, 3).
      b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
   2. Include with each Submittal a copy of the relevant Drawing, including relevant addendum updates.
      a. Indicate either compliance with a check (√) or deviation with a consecutive number (1, 2, 3).
      b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
      c. Provide field dimensions and relationship to adjacent or critical features of the Work or materials.

H. Contractor: Prepare Submittal information in sufficient detail to show compliance with specified requirements.
   1. Determine and verify quantities, field dimensions, product dimensions, specified design and performance criteria, materials, catalog numbers, and similar data.

2. Coordinate Submittal with other Submittals and with the requirements of the Contract Documents.
3. Check, verify, and revise Submittals as necessary to bring them into conformance with Contract Documents and actual field conditions.

I. Contractor: Prepare “Or Equal” Submittal information.
   1. Provide standard Submittal requirements.
      a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
   2. Provide reason the specified product is not being provided.
   3. Explain the benefits to the County for accepting the “Or Equal”.
   4. Itemized comparison of the proposed “Or Equal” with product specified including a list of significant variations:
      a. Design features.
      b. Design dimensions.
      c. Installation requirements.
      d. Operations and maintenance requirements.
      e. Availability of maintenance services and sources of replacement materials.
   5. Reference projects where the product has been successfully used:
      a. Name and address of project.
      b. Year of installation.
      c. Year placed in operation.
      d. Name of product installed.
      e. Point of contact: Name and phone number.
   6. Define impacts:
      a. Impacts to other contracts.
      b. Impacts to other work or products.
   7. Contractor represents the following:
      a. Contractor bears the burden of proof of the equivalency of the proposed “Or Equal”.
      b. Proposed “Or Equal” is equal or superior to the specified product.
      c. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed “Or Equal”, unless County requires a Special Warranty.
      d. Contractor will coordinate installation of accepted “Or Equal” into the Work and will be responsible for the costs to make changes as required to the Work.
      e. Contractor waives rights to claim additional costs caused by proposed “Or Equal” which may subsequently become apparent.

J. Contractor: Prepare substitution Submittal information.
   1. Provide standard Submittal requirements.
      a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
   2. Provide reason the specified product is not being provided.
   3. Explain the benefits to the County for accepting the substitution.
   4. Itemized comparison of the proposed substitution with product specified including a list of significant variations:
      a. Design features.
      b. Design dimensions.
      c. Installation requirements.

d. Operations and maintenance requirements.
e. Availability of maintenance services and sources of replacement materials.

5. Reference projects where the product has been successfully used:
   a. Name and address of project.
   b. Year of installation.
   c. Year placed in operation.
   d. Name of product installed.
   e. Point of contact: Name and phone number.
6. Define impacts:
   a. Impacts to Contract Price.
      1) Required license fees or royalties.
      2) Do not include costs under separate contracts.
      3) Do not include Engineer's costs for redesign or revision of Contract Documents.
   b. Impacts to Contract Time.
   c. Impacts to Contract Scope.
   d. Impacts to other contracts.
   e. Impacts to other work or products.
7. Contractor represents the following:
   a. Contractor shall pay associated costs for the Engineer to evaluate the substitution.
   b. Contractor bears the burden of proof of the equivalency of the proposed substitution.
   c. Proposed substitution does not change the design intent and will have equal performance to the specified product.
   d. Proposed substitution is equal or superior to the specified product.
   e. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed substitution, unless County requires a Special Warranty.
   f. Contractor will coordinate installation of accepted substitution into the Work and will be responsible for the costs to make changes as required to the Work.
   g. Contractor waives rights to claim additional costs caused by proposed substitution which may subsequently become apparent.

## 1.05 SUBMITTAL IDENTIFICATION NUMBERING

A. Number each Submittal using the format defined in the table below:

| | Spec Section Number | Dash | Initial Submittal - Sequential Number | Decimal Point | Subsequent Submittal Revisions Sequential Number |
|---|---|---|---|---|---|
| *Example 1 Description* | *Cast-In-Place Concrete* | | *8th initial Submittal* | | |
| | 00_30_30 | - | 0008 | | |
| *Example 2 Description* | *Cast-In-Place Concrete* | | *8th initial Submittal* | | *First revision to the 8th initial Submittal* |
| | 00_30_30 | - | 0008 | . | 1 |

## 1.06 SUBMITTALS IN ELECTRONIC MEDIA FORMAT

A. General: Provide all information in PC-compatible format using Windows® operating system as utilized by the County and Engineer.

B. Text: Provide text documents and manufacturer's literature in Portable Document Format (PDF).

C. Graphics: Provide graphic Submittals (Drawings, diagrams, figures, etc.) utilizing Portable Document Format (PDF).

## 1.07 SUBMITTAL PROCEDURE

A. Engineer: Review Submittal and provide response:
   1. Review description:
      a. Engineer will be entitled to rely upon the accuracy or completeness of designs, calculations, or certifications made by licensed professionals accompanying a particular Submittal whether or not a stamp or seal is required by Contract Documents or Laws and Regulations.
      b. Engineer's review of Submittals shall not release the Contractor from Contractor's responsibility for performance of requirements of Contract Documents. Neither shall the Engineer's review release the Contractor from fulfilling purpose of installation nor from the Contractor's liability to replace defective work.
      c. Engineer's review of Shop Drawings, samples, or test procedures will be only for conformance with design concepts and for compliance with information given in Contract Documents.
      d. Engineer's review does not extend to:
         1) Accuracy of dimensions, quantities, or performance of equipment and systems designed by the Contractor.
         2) Contractor's means, methods, techniques, sequences, or procedures, except when specified, indicated on the Drawings, or required by Contract Documents.

3) Safety precautions or programs related to safety which shall remain the sole responsibility of the Contractor.

e. Engineer can Approve or Not Approve any exception at their sole discretion.

2. Review timeframe:
   a. Except as may be provided in technical Specifications, a Submittal will be returned within 30 days.
   b. When a Submittal cannot be returned within the specified period, Engineer will, within a reasonable time after receipt of the Submittal, give notice of the date by which that Submittal will be returned.
   c. Engineer's acceptance of progress schedule containing Submittal review times less than those specified or agreed to in writing by the Engineer will not constitute Engineer's acceptance of review times.
   d. Critical Submittals:
      1) Contractor will notify Engineer in writing that timely review of a Submittal is critical to the progress of Work.
3. Schedule delays:
   a. No adjustment of Contract Times or Contract Price will be allowed due to Engineer's review of Submittals unless all of the following criteria are met:
      1) Engineer has failed to review and return first submission within the agreed upon time frame.
      2) Contractor demonstrates that delay in progress of Work is directly attributable to Engineer's failure to return Submittal within time indicated and accepted by Engineer.
4. Review response will be returned to the Contractor with one of the following dispositions:
   a. Approved:
      1) No Exceptions:
         a) There are no notations or comments on the Submittal and the Contractor may release the equipment for production.
      2) Make Corrections Noted - See Comments:
         a) The Contractor may proceed with the Work, however, all notations and comments must be incorporated into the final product.
         b) Resubmittal not required.
      3) Make Corrections Noted - Confirm:
         a) The Contractor may proceed with the Work, however, all notations and comments must be incorporated into the final product.
         b) Submit confirmation specifically addressing each notation or comment to the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the confirmation.
   b. Not Approved:
      1) Correct and Resubmit:
         a) Contractor may not proceed with the Work described in the Submittal.
         b) Contractor assumes responsibility for proceeding without approval.
         c) Resubmittal of complete Submittal package is required within 30 calendar days of the date of the Engineer's Submittal review response.

2) Rejected - See Remarks:
a) Contractor may not proceed with the Work described in the Submittal.
b) The Submittal does not meet the intent of the Contract Documents. Resubmittal of complete Submittal package is required with materials, equipment, methods, etc., that meet the requirements of the Contract Documents.

c. Receipt Acknowledged:
1) Filed for Record:
a) This is used in acknowledging receipt of informational Submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc.
2) With Comments - Resubmit:
a) This is used in acknowledging receipt of informational Submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc. Feedback regarding missing information, conflicting information, or other information that makes it incomplete can be made with comments.

B. Contractor: Prepare resubmittal, if applicable:
1. Clearly identify each correction or change made.
2. Include a response in writing to each of the Engineer's comments or questions for Submittal packages that are resubmitted in the order that the comments or questions were presented from the first and subsequent Submittals and numbered consistent with the Engineer's numbering.
a. Acceptable responses to Engineer's comments are listed below:
1) "Incorporated" - Engineer's comment or change is accepted and appropriate changes are made.
2) "Response" - Engineer's comment not incorporated. Explain why comment is not accepted or requested change is not made. Explain how requirement will be satisfied in lieu of comment or change requested by the Engineer.
b. Reviews and resubmittals:
1) Contractor shall provide resubmittals which include responses to all Submittal review comments separately and at a level of detail commensurate with each comment.
2) Contractor responses shall indicate how the Contractor resolved the issue pertaining to each review comment
a) Responses such as "acknowledged" or "noted" are not acceptable.
3) Resubmittals which do not comply with this requirement may be rejected and returned without review.
4) Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non-compliant Submittals.
5) Submittal review comments not addressed by the Contractor in resubmittals shall continue to apply whether restated or not in subsequent reviews until adequately addressed by the Contractor to the satisfaction of the reviewing and approving authority.

c. Any resubmittal that does not contain responses to the Engineer's previous comments shall be returned for revision and resubmittal. No further review by the Engineer will be performed until a response for previous comments has been received.

3. Resubmittal timeframe:
   a. Contractor shall provide resubmittal within 15 days.
   b. When a resubmittal cannot be returned within the specified period, Contractor shall notify the Engineer in writing.
4. Review costs:
   a. Costs incurred by the County as a result of additional reviews of a particular Submittal after the second time it has been reviewed shall be borne by the Contractor.
   b. Reimbursement to the County will be made by deducting such costs from the Contractor's subsequent progress payments.

## 1.08 PRODUCT DATA

A. Edit Submittals so that the Submittal specifically applies to only the product furnished.

B. Neatly cross out all extraneous text, options, models, etc., that do not apply to the product being furnished so that the information remaining is only applicable to the product being furnished.

C. Details:
1. Supplier name and address.
2. Subcontractor name and address.

D. Include:
1. Catalog cuts.
2. Bulletins.
3. Brochures.
4. Manufacturer's Certificate of Compliance: Signed by product manufacturer along with supporting reference data, affidavits, and tests, as appropriate.
5. Manufacturer's printed recommendations for installation of equipment.
6. Quality photocopies of applicable pages from manufacturer's documents.

E. Test reports including the following information:
1. Test description.
2. List of equipment used.
3. Name of the person conducting the test.
4. Date and time the test was conducted.
5. Ambient temperature and weather conditions.
6. All raw data collected.
7. Calculated results.
8. Clear statement if the test passed or failed the requirements stated in Contract Documents.
9. Signature of the person responsible for the test.

F. Certificates:
1. As specified in technical sections.

2. For products that will be in contact with potable water, submit evidence from a nationally recognized laboratory that the products comply with the requirements of the NSF 61 standard.

## 1.09 SHOP DRAWINGS

A. Contractor to field verify elevation, coordinates, and pipe material for pipe tie-in to pipeline or structure prior to the preparation of Shop Drawings.

B. Indicate Project-designated equipment tag numbers for Submittal of devices, equipment, and assemblies.

C. Details:
   1. Fabrication drawings: Drawn to scale and dimensioned.
   2. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
   3. Locations of conduit entrances and access plates.
   4. Component layout and identification.
   5. Weight.
   6. Finish.
   7. Temperature limitations, as applicable.
   8. Nameplate information.

D. Minor or incidental products and equipment schedules:
   1. Details:
      a. Shop Drawings of minor or incidental fabricated products will not be required, unless requested.
      b. Submit tabulated lists of minor or incidental products showing the names of the manufacturers and catalog numbers, with Product Data and Samples as required to determine acceptability.

## 1.10 SAMPLES

A. Details:
   1. Submit labeled samples.
   2. Samples will not be returned.
   3. Provide number of sample Submittals as below:
      a. Total: 2 minimum.
         1) County: 1.
         2) Engineer: 1.

## 1.11 DESIGN CALCULATIONS

A. Defined in technical sections:
   1. Calculations must bear the original seal and signature of a Professional Engineer licensed in the state of Florida and who provided responsible charge for the design.

## 1.12 SCHEDULES

A. Progress schedules: As specified in Section 01_32_21 - Schedules and Reports.

1. Each schedule submittal specified in these Contract Documents shall be submitted as a native backed-up file (.xer) of the scheduling program as specified in Section 01_32_21 - Schedules and Reports.
2. The schedule and all required reports shall also be submitted as a PDF file.
3. Schedule of values: As specified in Section 01_29_73 - Schedule of Values.
4. Schedule of submittals: As specified in Section 01_32_21 - Schedules and Reports.

B. Progress reports and quantity charts:
   1. As specified in Section 01_32_21 - Schedules and Reports.

## 1.13 REQUESTS FOR SUBSTITUTIONS (RFS)

A. As specified in Section 01_60_00 - Product Requirements.

## 1.14 REQUESTS FOR INFORMATION (RFI)

A. As specified.

## 1.15 CONTRACTOR'S PROFESSIONAL ENGINEER (P.E.) CERTIFICATION FORM

A. Submit a completed Contractor's P.E. Certification Form, provided in this Section, to comply with technical sections requirement for a professional engineer's certification from an engineer licensed in the state of Florida where required by applicable rule or law.

## 1.16 CLOSEOUT SUBMITTALS

A. Provide closeout submittals as specified in Section 01_77_00 - Closeout Procedures.

B. Operation and Maintenance Manuals: final documents shall be submitted as specified in Section 01_78_24 - Operation and Maintenance Manuals.

C. Extra materials, spare parts, etc.: Submittal forms shall indicate when actual materials are submitted.

# PART 2 PRODUCTS (NOT USED)

# PART 3 EXECUTION (NOT USED)

END OF SECTION

## ATTACHMENT A - CONTRACTOR SUBMITTAL TRANSMITTAL FORM

## CONTRACTOR SUBMITTAL TRANSMITTAL FORM

| | | | |
|---|---|---|---|
| **County:** | Click here to enter text. | **Date:** | MM/DD/YYYY |
| **Contractor:** | Click here to enter text. | **Project No.:** | XXXXX.XX |
| **Project Name:** | Click here to enter text. | **Submittal Number:** | 000 |
| **Submittal Title:** | Click here to enter text. | | |
| **To:** | Click here to enter text. | | |
| **From:** | Click here to enter text. | Click here to enter text. | |
| | Click here to enter text. | Click here to enter text. | |

| **Specification No. and Subject of Submittal/Equipment Supplier** | | | |
|---|---|---|---|
| **Spec ##:** | Spec ##. | **Subject:** | Click here to enter text. |
| **Authored By:** | Click here to enter text. | **Date Submitted:** | XX/XX/XXXX |

| **Submittal Certification** | |
|---|---|
| **Check Either (A) or (B):** | |
| ☐ | (A) We have verified that the equipment or material contained in this Submittal meets all the requirements specified in the project manual or shown on the Contract Drawings with no exceptions. |
| ☐ | (B) We have verified that the equipment or material contained in this Submittal meets all the requirements specified in the project manual or shown on the Contract Drawings, except for the deviations listed. |
| Certification Statement: By this Submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved Shop Drawings and all Contract requirements. | |
| **General Contractor's Reviewer's Signature:** | |
| **Printed Name:** | |
| In the event Contractor believes the Submittal response does or will cause a change to the requirements of the Contract, Contractor shall immediately give written notice stating that Contractor considers the response to be a Change Order. | |
| **Firm:** Click here to enter text. | **Signature:** **Date Returned:** XX/XX/XXXX |

| **PM/CM Office Use** | |
|---|---|
| Date Received GC to PM/CM: | |
| Date Received PM/CM to Reviewer: | |
| Date Received Reviewer to PM/CM: | |
| Date Sent PM/CM to GC: | |

# SECTION 01_41_00

# REGULATORY REQUIREMENTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Regulatory authorities and codes.

### 1.02 AUTHORITIES HAVING JURISDICTION (AHJ)

A. Also referred to as the permitting agency.

B. National Fire Protection Association (NFPA):
   1. NFPA 70: National Electrical Code, current edition.
   2. 8th Edition Florida Fire Prevention Code (NFPA 1-Uniform Fire Code-2023 edition, NFPA 101-Life Safety Code-2023 edition).

C. Florida Building Commission (FBC), with local amendments:
   a. Florida Building Code: Building – 2023.
   b. Florida Building Code: Energy – 2023.
   c. Florida Building Code: Existing Building – 2023.
   d. Florida Building Code: Fuel Gas – 2023.
   e. Florida Building Code: Mechanical – 2023.
   f. Florida Building Code: Plumbing – 2023.

D. Florida Building Code: Test Protocols for High Velocity Hurricane Zone – 2023.

### 1.03 APPLICABLE CODES

A. Design requirements:
   1. Building code:
      a. Florida Building Code: Building.
      b. Florida Building Code: Existing Building.
      c. Florida Building Code: Test Protocols for High Velocity Hurricane Zones.
   2. Electrical code:
      a. NFPA 70: National Electric Code.
   3. Energy conservation code:
      a. Florida Building Code: Energy.
   4. Fire code:
      a. 8th Edition Florida Fire Prevention Code, with local amendments.
   5. Mechanical codes:
      a. Florida Building Code: Mechanical.
      b. Florida Building Code: Fuel Gas.
   6. Plumbing code:
      a. Florida Building Code: Plumbing.

B. Local Requirements:
   1. Contractor shall be responsible for complying with the Collier County Water-Sewer District Utilities Standards Manual (CCWSDUS) applicable specifications, details, and guidelines. In case of discrepancy among the Contract Documents and the CCWSDUS documents, the most restrictive requirements shall govern. In the event that any conflicts cannot be resolved by reference to this provision, then County shall resolve the conflict in any manner which is acceptable to County and which comports with the overall intent of the Contract Documents.

C. Florida Department of Environmental Protection Drinking Water Section:
   1. Section 62-550 of the Florida Administrative Code.
   2. Section 62-555 of the Florida Administrative Code.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01_45_00

# QUALITY CONTROL

## PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Quality control and control of installation.
   2. Tolerances.
   3. References.
   4. Mock-up requirements.
   5. Authority and duties of County's representative or inspector.
   6. Sampling and testing.
   7. Testing and inspection services.
   8. Contractor's responsibilities.

## 1.02 QUALITY CONTROL AND CONTROL OF INSTALLATION

A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

B. Comply with manufacturers' instructions, including each step in sequence.

C. When manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. Perform Work by persons qualified to produce required and specified quality.

F. Verify field measurements are as indicated on Shop Drawings or as instructed by manufacturer.

G. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

H. When specified, products will be tested and inspected either at point of origin or at Work site:
   1. Notify Engineer in writing well in advance of when products will be ready for testing and inspection at point of origin.
   2. Do not construe that satisfactory tests and inspections at point of origin is final acceptance of products. Satisfactory tests or inspections at point of origin do not preclude retesting or re-inspection at Work site.

I. Do not ship products which require testing and inspection at point of origin prior to testing and inspection.

## 1.03 TOLERANCES

A. Monitor fabrication and installation tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. When Manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.

C. Adjust products to appropriate dimensions; position before securing products in place.

## 1.04 REFERENCES

A. ASTM International (ASTM):
   1. E329 - Standard for Agencies Engaged in Construction Inspection, Testing or Special Inspection.

B. National Institute of Standards and Technology (NIST).

## 1.05 PRODUCT REQUIREMENTS

A. For products or workmanship specified by association, trade, or other consensus standards, comply with requirements of standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of issue current on date of Contract Documents, except where specific date is established by code.

C. Obtain copies of standards where required by product specification sections.

D. When specified reference standards conflict with Contract Documents, request clarification from Engineer before proceeding.

## 1.06 MOCK-UP REQUIREMENTS

A. Tests will be performed under provisions identified in this Section and identified in respective product specification sections.

B. Assemble and erect specified items with specified attachment and anchorage devices, flashings, seals, and finishes.

C. Accepted mock-ups shall be comparison standard for remaining Work.

D. Where mock-up has been accepted by Engineer and is specified in product specification sections to be removed; remove mock-up and clear area when directed to do so by Engineer.

## 1.07 AUTHORITY AND DUTIES OF COUNTY'S REPRESENTATIVE OR INSPECTOR

A. County’s Project Representative employed or retained by County is authorized to inspect the Work.

B. Inspections may extend to entire or part of the Work and to preparation, fabrication, and manufacture of products for the Work.

C. Deficiencies or defects in the Work which have been observed will be called to Contractor's attention.

D. Inspector will not:
   1. Alter or waive provisions of Contract Documents.
   2. Inspect Contractor's means, methods, techniques, sequences, or procedures for construction.
   3. Accept portions of the Work, issue instructions contrary to intent of Contract Documents, or act as foreman for Contractor. Supervise, control, or direct Contractor's safety precautions or programs; or inspect for safety conditions on Work site, or of persons thereon, whether Contractor's employees or others.

E. Inspector will:
   1. Conduct on-site observations of the Work in progress to assist Engineer in determining when the Work is, in general, proceeding in accordance with Contract Documents.
   2. Report to Engineer whenever Inspector believes that Work is faulty, defective, does not conform to Contract Documents, or has been damaged; or whenever there is defective material or equipment; or whenever Inspector believes the Work should be uncovered for observation or requires special procedures.

## 1.08 SAMPLING AND TESTING

A. General:
   1. Prior to delivery and incorporation in the Work, submit listing of sources of materials, when specified in sections where materials are specified.
   2. When specified in sections where products are specified:
      a. Submit sufficient quantities of representative samples of character and quality required of materials to be used in the Work for testing or examination.
      b. Test materials in accordance with standards of national technical organizations.

B. Sampling:
   1. Furnish specimens of materials when requested.
   2. Do not use materials which are required to be tested until testing indicates satisfactory compliance with specified requirements.
   3. Specimens of materials will be taken for testing whenever necessary to determine quality of material.
   4. Assist Engineer in preparation of test specimens at site of work, such as soil samples and concrete test cylinders.

## 1.09 TESTING AND INSPECTION SERVICES

A. Contractor will employ and pay for specified services of an independent firm to perform Contractor quality control testing as required in the technical specifications for various work and materials.

B. County will employ and pay for specified services of an “County’s independent testing firm” certified to perform testing and inspection as required in the technical specifications for various work and materials.

C. The County’s independent testing firm will perform tests, inspections and other services specified in individual specification sections and as required by County and requested by the Engineer.

D. The qualifications of laboratory that will perform the testing, contracted by the County or by the Contractor, shall be as follows:
   1. Has authorization to operate in the state where the project is located.
   2. Meets “Recommended Requirements for Independent Laboratory Qualification,” published by American Council of Independent Laboratories.
   3. Meets requirements of ASTM E329.
   4. Laboratory Staff: Maintain full time specialist on staff to review services.
   5. Testing Equipment: Calibrated at reasonable intervals with devices of accuracy traceable to NIST or accepted values of natural physical constants.
   6. Will submit copy of report of inspection of facilities made by Materials Reference Laboratory of NIST during most recent tour of inspection, with memorandum of remedies of deficiencies reported by inspection.

E. Testing, inspections, and source quality control may occur on or off project site. Perform off-site testing inspections and source quality control as required by Engineer or County.

F. Contractor shall cooperate with County’s independent testing firm, furnish samples of materials, design mix, equipment, tools, storage, safe access, and assistance by incidental labor as requested.
   1. Notify Engineer and County’s independent testing firm 48 hours prior to expected time for operations requiring testing.
   2. Make arrangements with County’s independent testing firm and pay for additional samples and tests required for Contractor’s use.

G. Limitations of authority of testing Laboratory: County’s independent testing firm or Laboratory is not authorized to:
   1. Agency or laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.
   2. Agency or laboratory may not approve or accept any portion of the Work.
   3. Agency or laboratory may not assume duties of Contractor.
   4. Agency or laboratory has no authority to stop the Work.

H. Testing and employment of an County’s independent testing firm or laboratory shall not relieve Contractor of obligation to perform Work in accordance with requirements of Contract Documents.

I. Re-testing or re-inspection required because of non-conformance to specified requirements shall be performed by same County’s independent testing firm on instructions by Engineer. Payment for re-testing or re-inspection will be charged to Contractor by deducting testing charges from Contract Sum/Price.

J. The County's independent testing firm responsibilities will include:
   1. Test samples of mixes submitted by Contractor.
   2. Provide qualified personnel at site. Cooperate with Engineer and Contractor in performance of services.
   3. Perform specified sampling and testing of products in accordance with specified standards.
   4. Ascertain compliance of materials and mixes with requirements of Contract Documents.
   5. Promptly notify Engineer and Contractor of observed irregularities or non-conformance of Work or products.
   6. Perform additional tests required by Engineer.
   7. Attend preconstruction meetings and progress meetings when requested.

K. County's independent testing firm individual test reports:
   1. After each test, County's independent testing firm will promptly submit electronically report to Engineer and to Contractor.
   2. Test reports shall include at least the following information:
      a. Date issued.
      b. Project title and number.
      c. Name of inspector.
      d. Date and time of sampling or inspection.
      e. Identification of product and specifications section.
      f. Location in Project.
      g. Type of inspection or test.
      h. Date of test.
      i. Certified test results stamped and signed by a registered Engineer in the state where the project is located.
      j. Summary of conformance with Contract Documents.
      k. When requested by Engineer, the County's independent testing firm will provide interpretation of test results.

## 1.10 CONTRACTOR'S RESPONSIBILITIES

A. Cooperate with County's independent testing firm or laboratory personnel and provide access to construction and manufacturing operations.

B. Secure and deliver to County's independent testing firm or laboratory adequate quantities of representative samples of materials proposed to be used and which require testing.

C. Provide to County's independent testing firm or laboratory and Engineer preliminary mix design proposed to be used for concrete, and other materials mixes which require control by testing laboratory.

D. Submit product test reports electronically.

E. Furnish incidental labor and facilities:
   1. To provide access to construction to be tested.
   2. To obtain and handle samples at Work site or at source of product to be tested.
   3. To facilitate inspections and tests.

4. For storage and curing of test samples.

F. Notify County's independent testing firm or laboratory 48 hours in advance of when observations, inspections and testing is needed for laboratory to schedule and perform in accordance with their notice of response time.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01_60_00

# PRODUCT REQUIREMENTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Requirements for tangible materials, raw or manufactured, that become part of the project.

### 1.02 REFERENCES

A. International Organization for Standardization (ISO):
   1. 9001 - Quality Management Systems - Requirements.

B. NSF International (NSF).
   1. 61 - Drinking Water System Components - Health Effects.
   2. 372 - Drinking Water System Components – Lead Content.

C. Underwriters Laboratories, Inc. (UL).

D. American National Standards Institute (ANSI).

### 1.03 TERMINOLOGY

A. The words and terms listed below, are not defined terms that require initial capital letters, but, when this Section is referenced in other Specifications, have the indicated meaning.
   1. Calculations:
      a. Documentation of the process of transforming the design and prescriptive criteria into a design meeting the performance criteria.
   2. Certificates:
      a. An official document that attests a fact is in accordance with the Contract Documents.
   3. Manufacturer's instructions:
      a. Stipulations, directions, and/or recommendations issued by the manufacturer of the product addressing handling, storage, installation, protection, erection, and/or application of the product.
   4. Products:
      a. Raw materials, finished goods, equipment, systems, and shop fabrications that will become part of the Work.
   5. Product data:
      a. Information about the product, which is typically found in the manufacturer's catalogs or on their web site, including data sheets, bulletins, layout drawings, exploded views, and brochures.
   6. Samples:
      a. As defined in the General Conditions and Supplementary Conditions.

b. Full-size actual products or pieces of products intended to illustrate the products to be incorporated into the project. Sample submittals are often necessary for such characteristics as colors, textures, and other appearance issues.

7. Shop Drawings:
   a. As defined in the General Conditions and Supplementary Conditions.
   b. Shop Drawings are prepared specifically for the project to illustrate details, dimensions, and other data necessary for satisfactory fabrication or construction.
   c. Shop Drawings could include graphic line-type drawings and single-line diagrams.
8. Spare parts and materials:
   a. Duplicate parts necessary to replace a damaged or worn part of the product.
   b. Consumables such as operating fluids.
9. Special tools:
   a. Special wrenches, gauges, circuit setters, and other similar devices required for the proper operation or maintenance of a product that would not normally be in the Owner's tool kit and that have been specifically made for use on a product for assembly, disassembly, repair, or maintenance.
10. Submittals:
    a. As defined in the General Conditions and Supplementary Conditions.
    b. Samples, product data, Shop Drawings, and other materials that demonstrate how Contractor intends to conform to the Contract Documents.

## 1.04 SHIPMENT

A. Requirements prior to shipment of equipment:
   1. Engineer approved Submittals or other written documentation.
   2. Engineer approved Manufacturer’s Certificate of Source Testing as specified in the Technical Sections.
   3. Draft operations and maintenance manuals, as specified in Section 01_78_24 - Operation and Maintenance Manuals as specified in the Technical Sections.

B. Transport products by methods that avoid product damage.

C. Deliver products in undamaged condition in manufacturer's unopened containers or packaging.

## 1.05 DELIVERY AND HANDLING

A. Handle equipment in accordance with manufacturer's instructions.

B. Deliver products in undamaged condition in manufacturer's unopened containers or packaging.

C. Provide construction equipment and personnel to handle products by methods in accordance with manufacturer’s instructions.

D. Upon delivery, promptly inspect shipments:
   1. Verify compliance with Contract Documents, correct quantities, and undamaged condition of products.
   2. Acceptance of shipment does not constitute final acceptance of equipment.

E. Spare parts, maintenance products, special tools.
   1. Immediately store in accordance with the manufacturer's instructions.
   2. Store spare parts, maintenance products, and special tools in enclosed, weather-proof, and lighted facility during the construction period.
      a. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.
   3. With Owner's written request for advanced delivery of spare parts, maintenance products, and special tools.
      a. Deliver requested items and deduct them from the inventory list.
      b. Provide transmittal documentation.
   4. Store large items individually:
      a. Weight: Greater than 50 pounds.
      b. Size: Greater than 24 inches wide by 18 inches high by 36 inches long.
      c. Clearly labeled:
         1) Equipment tag number.
         2) Equipment manufacturer.
         3) Subassembly component, if appropriate.
         4) Store smaller items in spare parts box:
      d. Weight: Less than 50 pounds.
      e. Size: Less than 24 inches wide by 18 inches high by 36 inches long.
      f. Clearly labeled:
         1) Equipment tag number.
         2) Equipment manufacturer.
         3) Subassembly component, if appropriate.
         4) Spare parts and special tools box:
      g. Box material: Waterproof, corrosion resistant.
      h. Hinged cover:
         1) Locking hasp.
      i. Spare parts inventory list taped to underside of cover.
      j. Clearly labeled:
         1) “Spare Parts and/or Special Tools”.
         2) Equipment tag number.
         3) Equipment manufacturer.
         4) Subassembly component, if appropriate.

## 1.06 STORAGE

A. Storage of equipment to be in accordance with the manufacturer’s instructions.
   1. Including connection of motor heaters, lubrication, manually rotating shafts, etc.
   2. Contractor shall furnish a copy of the manufacturer’s instructions for storage to the Engineer prior to storage of equipment and materials.

B. Immediately store and protect products until installed in Work.

C. Furnish covered, weather-protected storage structures providing a clean, dry, noncorrosive environment for mechanical equipment, valves, architectural items, electrical and instrumentation equipment and special equipment to be incorporated into this project.

D. Store products with seals and legible labels intact.

E. Protect painted or coated surfaces against impact, abrasion, discoloration, and damage.

F. Storage of spare parts, maintenance products, special tools.
   1. Immediately store in accordance with the manufacturer's instructions.
   2. Store spare parts, maintenance products, and special tools in enclosed, weather-proof, and lighted facility during the construction period.
   3. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.
   4. Store large items individually:
      a. Weight: Greater than 50 pounds.
      b. Size: Greater than 24 inches wide by 18 inches high by 36 inches long.
      c. Clearly labeled:
         1) Equipment tag number.
         2) Equipment manufacturer.
         3) Subassembly component, if appropriate.
   5. Store smaller items in spare parts boxes:
      a. Weight: Less than 50 pounds.
      b. Size: Less than 24 inches wide by 18 inches high by 36 inches long.
      c. Clearly labeled:
         1) Equipment tag number.
         2) Equipment manufacturer.
         3) Subassembly component, if appropriate.
   6. Spare parts and special tools box:
      a. Box material: Waterproof, corrosion resistant.
      b. Hinged cover with locking hasp:
      c. Inventory list taped to underside of cover.
         1) Clearly labeled:
            a) “Spare Parts and/or Special Tools”.
            b) Equipment tag number.
            c) Equipment manufacturer.
            d) Subassembly component, if appropriate.

G. Exterior storage of fabricated products:
   1. Place on aboveground supports that allow for drainage.
   2. Cover products subject to deterioration with impervious sheet covering.
   3. Provide ventilation to prevent condensation under covering.

H. Store moisture sensitive products in watertight enclosures.

I. Store loose granular materials on solid surfaces in well-drained area.
   1. Prevent materials mixing with foreign matter.
   2. Provide access for inspection.

J. Provide an equipment log and stored products log with monthly pay applications.
   1. Include: Storage location, equipment or product identification, date stored, date of inspection/maintenance, date removed from storage, copy of manufacturer's recommended storage guidelines, description of inspection/maintenance activities performed, and signature of party performing inspection/maintenance.

K. When needed and approved by the Engineer, offsite storage location shall be within 20 miles of the project site.
   1. Provide proof of insurance coverage for products stored offsite.

L. Payment will not be made for equipment and materials improperly stored or stored without providing Engineer with the manufacturer's instructions for storage.

## PART 2 PRODUCTS

### 2.01 GENERAL REQUIREMENTS

A. Provide products as Engineer has approved by the Submittal process or by other written documents.

B. Provide products by same manufacturer when units are of similar nature, unless otherwise specified.

C. Provide like parts of duplicate units that are interchangeable.

D. Provide equipment or product that has not been in service prior to delivery, except as required by tests.

E. Provide products produced by manufacturers regularly engaged in the production of these products.

F. Provide products that bear approvals and labels as specified such as Factory Mutual (FM), Underwriters Laboratory (UL), or National Sanitation Foundation (NSF International) that are acceptable to the Authority Having Jurisdiction.

### 2.02 MATERIAL

A. Dissimilar metals:
   1. Separate contacting surfaces with dielectric material.
   2. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.

B. Edge grinding:
   1. Sharp projections of cut or sheared edges of ferrous metals which are not to be welded shall be ground to a radius required to ensure satisfactory paint adherence.

C. Use anti-galling compound on threads of stainless steel fasteners during factory assembly.

D. Provide anti-galling compound with stainless steel fasteners shipped for field assembly.

E. Aluminum in contact with concrete or masonry: Apply epoxy mastic as specified in Section 09_96_01 - High-Performance Coatings, coating system EPX-M-5.

F. Pipes:
   1. Provide new pipe manufactured for the following:
      a. Piping 24-inch diameter and larger.
      b. AWWA C200 steel piping.
   2. Piping provided from manufacturers/distributors inventory is subject to the following condition:
      a. Provide proof pipe manufactured more than 6 months prior to delivery was stored properly and the material and/or coating was not subjected to ultraviolet (UV) degradation.
   3. Mark each length of pipe in accordance with applicable standards.

G. All wetted materials used in the production of potable water, or in contact with the water or chemicals used to treat water, shall comply with NSF 60/61 or other acceptable standards per F.A.C. 62-555.

## 2.03 PRODUCT SELECTION

A. When products are specified without named manufacturers, provide products that meet or exceed the Specifications.

B. When products are specified with names of manufacturers but no model numbers or catalog designations, provide products by one of named manufacturers that meet or exceed specifications.

C. When products are specified with names of manufacturers and model numbers or catalog designations, provide products with model numbers or catalog designations by one of the named manufacturers.

D. When products are specified with names of manufacturers, but with brand or trade names, model numbers, or catalog designations by one manufacturer only, provide:
   1. Products specified by brand or trade name, model number, or catalog designation.
   2. Products by another named manufacturers proven, in accordance with requirements for an “or equal”, including Engineer’s approval, to meet or exceed quality, appearance and performance of specified brand or trade name, model number, or catalog designation.

E. When products are specified with only one manufacturer followed by “or Equal,” provide:
   1. Products meeting or exceeding Specifications by specified manufacturer.
   2. Engineer deemed “or equal” evidenced by an approved Shop Drawing or other written communication.

F. When products are specified by naming 2 or more manufacturers with 1 manufacturer as a “Basis of Design”:
   1. Any of the named manufacturers can be submitted.
   2. If the product submitted is not by the named “Basis of Design” product and requires a change in the scope (dimensions, configuration, physical properties, etc.), schedule (longer lead time), or budget, the Contractor must submit a substitution request.

## 2.04 SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. Provide spare parts and maintenance products as required by Technical Sections.
   1. Submit completed Attachment A - Spare Parts, Maintenance Products, and Special Tools Inventory List.

B. Provide one set of special tools required to install or service the equipment.

C. Box, tag, and clearly mark items.

D. Contractor is responsible for spare parts, maintenance products, and special tools until acceptance by Owner.

# PART 3 EXECUTION

## 3.01 INSTALLATION

A. Inspect equipment or product prior to product installation.

B. Repaint or recoat damaged painted or coated surfaces.

C. Use anti-galling compound on stainless steel threads used for field assembly.

## 3.02 PROTECTION AFTER INSTALLATION

A. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations.
   1. Remove covering when no longer needed.
   2. Replace corroded, damaged, or deteriorated equipment, product, or parts before acceptance of the project.

B. Update equipment log with monthly pay applications.
   1. Data includes as a minimum: Description of maintenance activities performed in accordance with the manufacturer’s recommendation and industry standards and signature of party performing maintenance.

END OF SECTION

# ATTACHMENT A - SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS INVENTORY LIST

## SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS INVENTORY LIST

**Owner:** _____ **Date:** _____

**Contractor:** _____ **Project No.:** _____

**Project Name:** _____

| Inventory List | | | | |
|---|---|---|---|---|
| Spec Number: _____ | | Spec Title _____ | | |
| Equipment Tag No.: _____ | | Equipment Manufacturer: _____ | | |
| **Quantity** | **Subassembly Component** | **Description** | **Manufacturer's Part Number** | **Storage Location** |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

# SECTION 01_71_23

# FIELD ENGINEERING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Field engineering to establish lines and grades for the Work.

### 1.02 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Qualifications of the professional land surveyor or licensed civil engineer with the authority to provide land surveying in Florida that will be performing the field engineering.

C. Pre-Excavation Report.

### 1.03 PRE-EXCAVATION REPORT

A. Prior to the start of the Work, create a report confirming the verification of the following data:
   1. Site elevation.
   2. Existing structures, including, but not limited to, buildings, manholes (sanitary, storm, electrical, and other), drainage inlets:
      a. Location coordinates.
      b. Top of wall elevation and coordinates.
      c. Floor elevations.
      d. Invert elevations.
   3. Existing utilities
   4. Proposed building corners, tank, and equipment locations.
   5. Verify existing electrical, instrumentation, and phone utilities.

B. Incorporate information from Pre-Excavation Report into the Record Drawings.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

### 3.01 SURVEY REFERENCE POINTS

A. Basic reference line, a beginning point on basic reference line, points with referenced coordinates, and a benchmark will be provided by the Owner.

B. From these reference points, establish other control and reference points as required to properly lay out the Work.

C. Locate and protect control points prior to starting site work, and preserve permanent reference points during construction:
   1. Make no changes or relocations without prior written notice.
   2. Replace Project control point, when lost or destroyed, in accordance with original survey control.

D. Set monuments for principal control points and protect them from being disturbed and displaced:
   1. Re-establish disturbed monuments.
   2. When disturbed, postpone parts of the Work that are governed by disturbed monuments until such monuments are re-established.

## 3.02 PROJECT SITE SURVEY REQUIREMENTS

A. Establish minimum of 2 permanent benchmarks on site referenced to data established by survey control points.

B. Record permanent benchmark locations with horizontal and vertical data on Project Record Documents.

C. Perform verifications and checking in accordance with industry standard surveying practice.

D. Maintain complete, accurate log of control points and survey.

E. Affix civil engineer's or professional land surveyor's signature and license number to Record Drawings to certify accuracy of information shown.

## 3.03 CONSTRUCTION STAKES, LINES, AND GRADES

A. Execute the Work in accordance with the lines and grades indicated.

B. Make distances and measurements on horizontal planes, except elevations and structural dimensions.

## 3.04 QUALITY CONTROL

A. Accuracy of stakes, alignments, and grades may be checked randomly by the Engineer:
   1. Notice of when checking will be conducted will be given.
   2. When notice of checking is given, postpone parts of the Work affected by stakes, alignments, or grades to be checked until checked.
   3. Engineer's check does not substitute or complement required field quality control procedures.

## 3.05 RECORD DOCUMENTS

A. Prepare and submit Record Documents as specified in Section 01_77_00 - Closeout Procedures.

B. Provide certified site survey including buildings, benchmarks, and appurtenances sealed and signed by professional land surveyor or duty authorized licensed civil engineer.
   1. Submit to permitting agency, as required.

END OF SECTION

**SECTION 01_75_17**

**COMMISSIONING**

**TABLE OF CONTENTS**

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Commissioning.

### 1.02 DEFINITIONS

A. Commissioning: The process of planning for, testing of, and start-up of systems, subsystems, equipment, components, and devices of the Work to demonstrate, through documented verification, that the Work has successfully met the Contract Documents. It includes training the County's staff on operation and maintenance of the installed Work.

B. Commissioning Phases: The activities of commissioning are grouped into the phases defined in the following table.
   1. Table 1 - Commissioning Phases.

| TABLE 1 - COMMISSIONING PHASES | | |
|---|---|---|
| **Planning Phase** | **Testing and Training Phase** | **Start-Up Phase** |
| Draft Test Plans | Source Testing:<br>• Documentation | Start-Up:<br>• Documentation<br>• County Training |
| | Installation Verification:<br>• Documentation<br>• County Training | |
| | Functional Testing:<br>• Documentation<br>• County Training | |

   2. Attachment A provides Commissioning Flowcharts.

C. Component: A part of a system that does not have an electrical connection or internal electronics. Examples: Piping and pressure gauges.

D. Device: A part of a system that has electrical connections or internal electronics. Examples: Level transmitter or pressure transmitter.

E. Electrical Energization Plan: A plan to manage how and when power is applied to electrical equipment.

F. Equipment: A factory or field assembled apparatus that performs an identifiable function. Examples: Pumps, motors, VFDs, MCCs.

G. Functional Testing: Testing performed on a completed subsystem or system to demonstrate that the system meets the specified requirements. Example systems: Backwash system, dewatering system.

H. Installation Verification: Testing to demonstrate that equipment or system and associated components or devices have been properly installed. Example equipment: Pumps, meters, and blowers with associated piping.

I. Manufacturer's Certificate of Functional Compliance: The form completed by the manufacturer to confirm that testing of the installed equipment or system has been performed and the results conform to the specified performance. The form is provided in Attachment D provided at the end of this Section.

J. Manufacturer's Certificate of Installation Verification: The form completed by the manufacturer to confirm that the equipment or system is installed in conformance with the Contract. The form is provided in Attachment C at the end of this Section.

K. Manufacturer's Certificate of Source Testing: The form completed by the manufacturer to confirm that the specified source tests have been performed and the results conform to the specified requirements. The form is provided in Attachment B at the end of this Section.

L. County Training: The County's staff is trained by the Contractor, with assistance from manufacturer, to operate and maintain the completed Work. This is sometimes referred to as Vendor Specific Training.

M. Process Stream: A series of liquid or solids flow processes that are designed to improve the water quality to meet regulatory permit requirements.

N. Source Testing: Test equipment or products for performance at point of manufacture or assembly for the requirements specified in the Contract Documents. Also referred to as factory testing and factory acceptance testing (FAT).

O. Start-Up: Operating the Work with process water to verify the Work meets the Contract Documents.

P. Start-Up Phase: The phase when Start-Up occurs.

Q. Subsystem: A grouping of equipment, components, and devices that is a part of a larger system and that perform a single definable function. Examples: Sand filters, filter backwash.

R. System: A grouping of equipment, components, and devices that perform a single definable function. If a system is a part of a larger system, it is referred to as a subsystem.
   1. Examples: Flocculation and sedimentation, filtration.

S. System Testing: Testing of a completed system for an extended time period. Examples: Headworks, filtration.

T. Water Management Plan: A plan to manage the test water used for commissioning from source to disposal. The test water may be clean water, potable water, non-potable water, or process water (e.g., raw water, plant water, sludge). The plan demonstrates how water will be produced, conveyed, treated, disposed of as directed by the plant manager, and/or recycled.

## 1.03 SUBMITTALS

A. Project Commissioning:
   1. Commissioning Coordinator's qualifications.
      a. Submit to Engineer no later than 30 days after Notice to Proceed.
      b. Describe previous similar experience on similar projects with a list of references including phone numbers.
      c. Provide names and qualifications of commissioning assistants, if applicable.
   2. Schedules:
      a. Commissioning Schedule containing all commissioning activities.
      b. County Training Schedule.
   3. Test Plans:
      a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
      b. Submit final Test Plan a maximum of 60 calendar days prior to testing.
      c. Engineer approval of final Test Plan required prior to start of testing.
   4. Test Reports:
      a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
      b. Submit final Test Report a maximum of 30 calendar days after testing.

B. Technical Sections Commissioning:
   1. Manufacturer's representative's qualifications.
      a. Submit to Engineer no later than 30 days in advance of required services.
      b. Representative's name, phone, and e-mail address:
         1) May use 2 representatives: 1 for field testing and 1 for County Training.
         2) Provide resume stating instructor's technical expertise and instructional technology skills and experience.
   2. Test Plans:
      a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
      b. Submit final Test Plan a maximum of 60 calendar days prior to testing.
      c. Engineer approval of final Test Plan required prior to start of testing.
   3. Test Reports:
      a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
         1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
      b. Submit final Test Report a maximum of 30 calendar days after testing.
   4. Manufacturer's representatives field notes and data.
   5. County Training:
      a. Prior to the training session:
         1) Training instructor qualifications.

2) Training course materials: Due 30 calendar days prior to initial training session.
    a) If County requires, Continuing Education Units (CEUs), submit training materials to state regulatory agency in sufficient time to obtain approval for training prior to the training.
    b) Drafts of training agenda, lesson plan, presentation, handouts, and list of audio-visual aids.
    c) Format: 1 electronic copy in the format and 3 hard copies organized in notebooks.

b. Post training session:
    1) Training course materials: Due 14 calendar days after class completion.
        a) Recordings.
        b) Class attendance sheet.
        c) Final version of training agenda, final lesson plan, presentation, handouts, and audio-visual aids.
        d) Format: 1 electronic copy in the format and 3 hard copies organized in notebooks.
    2) Provide materials for all sessions of the class in a single transmittal.
    3) If the County requires training CEUs, issue training CEU certificates approved by the state regulatory agency to County's staff who successfully completed the training.

## 1.04 COMMISSIONING COORDINATOR (CC)

A. Responsibilities include the following:
    1. Become thoroughly familiar with Contract Commissioning requirements.
    2. Provide the primary interface with Engineer and County for Commissioning efforts.
    3. Lead Commissioning efforts - all phases and tasks.
    4. Coordinate training efforts.
    5. Meetings:
        a. CC is responsible for setting Commissioning coordination meeting dates and times, as well as preparing the agendas and meeting minutes.
        b. CC shall conduct Commissioning progress meetings throughout construction, to plan, scope, coordinate, and schedule future activities, resolve problems, etc.
        c. Frequency: Monthly minimum. Increase frequency as needed based on complexity and quantity of Commissioning activities.

B. CC on-site:
    1. Testing and Training Phase: Full-time.
    2. Start-Up Phase: Full-time.

## 1.05 MANUFACTURER'S REPRESENTATIVES

A. Qualifications: As specified below and in the Technical Sections:
   1. For Installation and Functional Testing:
      a. Factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment/system with full authority by the equipment/system manufacturer to issue the certifications required of the manufacturer.
   2. Training instructor qualifications:
      a. Provide resume stating instructor's technical preparation and instructional technology skills and experience.
      b. If CEUs are required, the operator training instructors must comply with state regulatory.
      c. Knowledgeable in the equipment/system for which they are training.
      d. Experienced in conducting classes.
      e. Sales representatives are not qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.
   3. Representatives to be approved by County and Engineer.
   4. No substitute representatives without written approval by County and Engineer.

B. Duties:
   1. Determine if additional time and/or trips (beyond those specified in the Technical Sections) is required to perform the specified services.
   2. Coordinate services in accordance with the Contractor's project schedule up to and including making multiple trips to the project site when there are separate milestones associated with installation of each occurrence of manufacturer's equipment.
   3. Perform on-site services as specified in the Technical Sections.
   4. Provide daily copies of manufacturer's representatives field notes and data to Contractor.

## 1.06 PLANNING PHASE

A. Overview of Planning Phase:
   1. Define approach and timing for Commissioning.
   2. Obtain Engineer approval of draft Test Plans.

B. Test Plans.
   1. Define approach and timing for:
      a. Testing and Training Phases.
         1) Major systems, with separate plans for each system.
      b. Start-Up Phase.
   2. Source Test (Factory Acceptance Test) and Functional Test Plans:
      a. As specified in this Section and other Technical Sections.
      b. Based on approved Shop Drawings.
      c. Prepared by the Contractor.
      d. Include the following items for each test:
         1) Purpose of the test.

2) Identification of each item of equipment/system to be tested, including system designation, location, tag number, control loop identifier, etc.
3) Description of the pass/fail criteria that will be used.
4) Listing of pertinent reference documents (Contract and industry standards or sections applicable to the testing).
a) Credentials of test personnel.
5) Test equipment:
a) Include Product Data for the test equipment.
b) Appropriate calibration records.
(1) Drawings or photographs of test stands and/or test apparatus.
6) Duration: Determine test durations with County's input.
7) Detailed step-by-step test procedures.
a) Level of detail shall be sufficient for the witness to follow the steps.

e. Define for Functional Testing:
1) Required temporary systems (pumps, piping, etc.).
2) Shutdown requirements for existing systems.

f. Furnish labor, power, tools, equipment, instruments, and services required for and incidental to testing activities.

3. Test forms minimum requirements:
a. Name of product to be tested.
b. Test date.
c. Names of persons conducting the test.
d. Names of persons witnessing the test, where applicable.
e. Test data.
f. Applicable project requirements as specified in the Technical Sections.
g. Check offs for each completed test or test step.
h. Place for signature of person conducting tests and for the witnessing person, as applicable.

4. County responsibilities:
a. County will schedule staff within the constraints of their workloads.
1) Those who will participate in this test have existing full-time work assignments, and testing is an additional assigned work task, therefore, scheduling is imperative.
2) Treatment facilities are typically operated on an around-the-clock basis and are staffed in work shifts.
1) Maximum hours per day available for commissioning activities: 4.
2) Days available for commissioning activities: Monday to Thursday.
3) Scheduling coordination with the CC.

5. CC is responsible for the following:
a. Coordinate schedule with the County's personnel and manufacturer's representatives (instructors).

C. Test Reports:
1. Minimum requirements:
a. Title.
b. Abstract.
c. Equipment.
d. Procedures.

e. Results.
    1) Complete disclosure of the calculation methodologies.
f. Conclusions.
g. Signature by an authorized party.
h. Appendices.
    1) Completed test forms signed by witnesses.

2. Water Management Plan:
    a. Requirements:
        1) Demonstrate how water will be produced, conveyed, treated, recycled, and or disposed until testing verifies specified requirements.
3. Commissioning Schedule:
    a. Content:
        1) Comply with Attachment G - Functional Testing Requirements and provide activities organized by system and subsystem.
        2) Include:
            a) Source Testing when required.
            b) Functional Testing.
            c) County Training.
        3) Comply with Attachment F - Commissioning Roles and Responsibilities Matrix.
    b. Procedures:
        1) Submit Commissioning Schedule as specified in Section 01_32_21 - Schedules and Reports.

## 1.07 TESTING AND TRAINING PHASE

A. Overview of Testing and Training Phase:
    1. General:
        a. Contractor tests the Work to verify it meets the Contract requirements.
        b. Contractor trains the County to operate and maintain the Work.
    2. Contractor responsibilities:
        a. Furnish labor, tools, equipment, instruments, and services required for and incidental to completing Commissioning activities in accordance with the approved Commissioning Plans.
    3. County responsibilities:
        a. Furnish labor, and services required for and incidental to completing Commissioning activities in accordance with the approved Commissioning Plans.
        b. County provided services, equipment, and/or materials to be as specified in Section 01_11_00 - Summary of Work.

B. Source Testing:
    1. As specified in the Technical Section.
    2. Source Test Plan:
        a. Engineer approval of Source Test Plan required prior to testing.
    3. Witnessed in person:
        a. As specified in the Technical Section.

b. Contractor is responsible for trip costs associated with County's and Engineer's representatives.
    1) Transportation:
        a) Travel 1 day on commercial airline to site including air flight costs and $1,600 allowance per person per day.
        b) Travel 1 day on commercial airline from site including air flight costs and $1,600 allowance per person per day.
        c) Rental car from hotel to and from the test site.
    2) Hotel/Meals:
        a) Hotel with an American Automobile Association 4 star rating or equivalent for single occupancy room per person per day.
        b) Meal allowance of $60 per person per day.

4. Virtual witness testing:
    a. As specified in the Technical Sections.
    b. Contractor is responsible for costs associated with virtual witness.
    c. Provide the following:
        1) An agenda detailing start time of each major phase in the procedure defined in the approved Test Plan.
        2) A dedicated operator (separate from the test technician) to operate the camera, provide commentary throughout test, and inspect devices at the request of the attendees.
    d. Online meeting platform: ZOOM, Microsoft Teams, or equal.
    e. Share video through a high-definition camera.
    f. Establish methods to communicate, convey, and record information clearly even in environments with loud background noise.
        1) Electronic feed for screen sharing of the control panel, HMI, or other screens used throughout testing.
        2) Provide recording of virtual sharing within 1 day after testing.
    g. Test run of virtual sharing a minimum of 1 week prior to the test:
        1) Use current record documents in PDF format.
        2) Provide recording of virtual sharing within 1 day after the test run.
        3) Engineer approval of test run virtual sharing is required before Source Testing.
5. If the Source Test is not ready on the scheduled date or if the Source Test fails:
    a. Contractor is responsible for associated costs:
        1) First test costs that are non-refundable, if applicable.
        2) Repeat test costs:
            a) Trip costs, if applicable.
        3) Virtual witness costs, if applicable.
            a) Witness labor costs:
                (1) Travel time and witness time are included, if applicable.
                (2) The greater of $200 per hour or $1,600 per day.
6. Source Testing is complete after successful testing, submittal of test report, and Manufacturer's Certificate of Source Testing.
7. Engineer approval of Source Testing Report is required.

C. Installation Verification:
1. Overview:
    a. Verifying the installation of equipment to be in accordance with Manufacturer's Instructions.

2. Prerequisite:
    a. Engineer approval of Source Testing Report.
3. Perform checks:
    a. Structural anchorage check.
    b. Electrical energization check.
        1) As specified in the flowchart shown in Attachment A.
    c. Health and safety check.
4. Submit Manufacturer's Certificate of Installation Verification.
5. Engineer approval of Manufacturer's Certificate of Installation Verification is required.

D. Functional Testing:
1. Overview:
    a. Testing the function of a system or subsystem.
2. Prerequisites:
    a. Engineer approval of Manufacturer's Certificate of Installation Verification.
    b. Engineer approval of Functional Test Plan required prior to testing.
    c. Draft Operations and Maintenance Manual as specified in Section 01_78_24 - Operations and Maintenance Manual.
    d. Completed pipe, valve, and gate labeling of system or subsystem.
3. Witnessed.
4. Discipline checks:
    a. Verify support systems function properly, such as seal water, pipes, valves, etc.
    b. As specified in the individual Technical Sections.
5. Consecutive Day Test:
    a. Operate the Work as specified in Attachment G - Functional Testing Requirements and as specified in the individual Technical Sections.
        1) Successful completion of subsystem testing required prior to system testing.
    b. Failure response time:
        1) Be equipped and ready to provide emergency repairs, adjustments, and corrections to comply with the "Significant Interruption Duration" requirements as specified in Attachment G - Functional Testing Requirements.
    c. Duration:
        1) As specified in Attachment G - Functional Testing Requirements.
        2) Restart the consecutive day test when the system performance failures exceed the "Significant Interruption Duration" time period specified in Attachment G - Functional Testing Requirements.
            a) Individual equipment/system failures that are corrected within the "Significant Interruption Duration" time specified in Attachment G - Functional Testing Requirements shall not require the consecutive day test to be restarted unless the failure recurs.
            b) Engineer has the authority to reject the consecutive day test if individual equipment/system failures are repetitive.
6. Instrumentation and controls tests.
    a. Loop Validation Tests.

b. Complete End-to-End Testing (CEET):
1) Signal are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.

7. Restore to condition prior to testing.
8. Submit Manufacturer's Certificate of Functional Compliance.
9. Engineer approval of Manufacturer's Certificate of Functional Compliance is required.

E. Documentation:
1. Provide records generated during Commissioning Phase of Project, including, but not limited to:
a. Training documentation.
b. Manufacturer's Certificate of Source Testing.
c. Manufacturer's Certificate of Installation Verification.
d. Manufacturer's Certificate of Functionality Compliance.
e. Daily logs of equipment/system testing identifying tests conducted and outcome.
f. Test forms and documentation.
g. Functional Testing results.
h. Logs of time spent by manufacturer's representatives performing services on the job site.
i. Equipment lubrication records.
j. Electrical phase, voltage, and amperage measurements.
k. Insulation resistance measurements.
l. Bearing temperature measurements.
m. Data sheets of control loop testing including testing and calibration of instrumentation devices and setpoints.
n. Provide: 1 electronic copy in format and 3 hard copies organized in notebooks.
o. Store the data within 24 hours of the test or document creation in the project system.
p. Due date: Within 14 calendar days of Substantial Completion.
2. Engineer approval of documentation is required.

F. County Training:
1. Train County's staff on the operation and maintenance of the equipment/system.
2. Train on each topic of the approved Operation and Maintenance Manual.
a. Include classroom instruction and field demonstration with all necessary tools and test equipment.
3. Training tailored to the skills and job classifications of the staff attending the classes (e.g., plant superintendent, treatment plant operator, maintenance technician, electrician, etc.).
4. Training outcomes:
a. County's staff can safely operate, maintain, and repair the equipment/systems provided as recommended by the manufacturer.
5. Training plan:
a. CC shall meet with Engineer and County's designated training coordinator to develop list of personnel to be trained and to establish expected training outcomes and objectives at least 60 calendar days prior to commissioning of equipment/system.

b. Coordinate and arrange for manufacturer's representatives to provide both classroom-based learning and field (hands-on) training, based on training module content and stated learning objectives.
c. Conduct classroom training at location designated by County.
d. Scope and sequence:
1) Plan and schedule training in the correct sequence to provide prerequisite knowledge and skills to trainees.
a) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
2) If multiple classes are needed to meet the training objectives, they shall be included in the training plan.

6. County Training Schedule:
a. Schedule County's staff training within the constraints of their workloads.
1) Those who will participate in this training have existing full-time work assignments, and training is an additional assigned work task, therefore, scheduling is imperative.
2) County staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
b. Training scheduling coordination:
1) CC is responsible for the following:
a) Coordinate schedule for training periods with the County's personnel and manufacturer's representatives (instructors).
2) Complete County Training no sooner than 15 calendar days prior to Functional Testing of each system.
c. Class logistics:
1) Delivery time minimum: 2 hours.
2) Delivery time maximum: 4 hours.
3) Class agenda:
a) Refreshment break: One 10-minute break.
b) Meal break: One 45-minute break, unless otherwise specified.
c) Schedule refreshment breaks and meal breaks to meet the class needs and County work rules.
4) Schedule specific sessions:
a) Minimum of 30 days in advance to allow County staffing arrangements to take place.
b) At the times requested by the County, within the period 7 a.m. to 7 p.m. Monday through Friday.
(1) Times scheduled will be at County's discretion.
c) County approval and confirmation required for session schedules.
d) Provide minimum of 2 sessions for each class unless otherwise noted.
(1) The purpose of having multiple sessions on each class is to accommodate the attendance of as many County personnel working different shifts as possible.
e) A maximum of 1 session per day for each class.
d. Number of students:
1) Engineer will confirm the headcount 1 week prior to the class, so that the instructor can provide the correct number of training aids for students.

7. Submittals:
    a. Submit Training Plan Schedule 30 calendar days before the first scheduled training session, including but not limited to lesson plans, participant materials, instructor's resumes, and training delivery schedules.
    b. Submit training documentation including the following:
        1) Training plan:
            a) Training modules.
            b) Scope and sequence statement.
            c) Contact information for manufacturer's instructors including name, phone, and e-mail address.
            d) Instructor qualifications.
        2) Training program schedule:
            a) Format: Bar chart:
                (1) Include in the Project Progress Schedule.
            b) Contents:
                (1) Training modules and classes.
8. Lesson plans:
    a. Divide training into discrete modules appropriate for the equipment and trades.
    b. State performance-based learning objectives in terms of what the trainees will be able to do at the end of the lesson.
    c. Define student conditions of performance and criteria for evaluating instructional success.
    d. Minimum requirements:
        1) Hands-on demonstrations planned for the instructions.
        2) Cross-reference training aids.
        3) Planned training strategies such as whiteboard work, instructor questions, and discussion points or other planned classroom or field strategies.
        4) Attach handouts cross-referenced by section or topic in the lesson plan.
        5) Indicate duration of outlined training segments.
    e. Provide instruction lesson plans for each trade:
        1) Detailed component description:
            a) Identify each component function and describe in detail.
            b) Identify equipment's mechanical, electrical, and electronic components and features.
            c) Where applicable, group relative components into subsystems.
            d) Identify and describe in detail equipment safety features, permissive and controls interlocks.
        2) Equipment operation:
            a) Describe equipment's operating (process) function and system theory.
            b) Describe equipment's fundamental operating principles and dynamics.
            c) Identify support equipment associated with the operation of subject equipment.
            d) Detail the relationship of each piece of equipment or component to the subsystems, systems, and process.

e) Cite hazards associated with the operations, exposure to chemicals associated with the component, or the waste stream handled by the component.
f) Specify appropriate safety precautions, equipment, and procedures to eliminate, reduce, or overcome hazards.

3) Define Preventative Maintenance (PM) inspection procedures required on equipment in operation, spot potential trouble symptoms (anticipate breakdowns), and forecast maintenance requirements (predictive maintenance).
a) Review preventive maintenance frequency and task analysis table.

4) Define equipment Corrective Maintenance (CM) troubleshooting:
a) Describe recommended equipment preparation requirements as they relate to specific craft problems.
b) Identify and describe the use of any special tools required for maintenance of the equipment as they relate to specific craft problems.
c) Provide component specific troubleshooting checklists as they relate to specific craft problems.
d) Describe component removal/installation and disassembly/assembly procedures for specific craft repairs.
e) Perform at least 2 hands-on demonstrations of common corrective maintenance repairs.

5) Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

9. Training instruction format:
a. The training for operations and maintenance personnel shall be provided as 1 entity.
b. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
c. Lecturing should be less than 30 percent of class time.
d. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture to support training objectives.
e. Conduct hands-on instruction according to the following descriptions:
1) Present hands-on demonstrations of at least the following tasks:
a) Proper start-up, shutdown, and normal and alternative operating strategies.
b) Common corrective maintenance repairs for each group.
c) Recommended procedures to check/test equipment/system following a corrective maintenance repair.
d) Preventative maintenance points.
e) Calibration, if applicable.

2) Use tools and equipment provided by manufacturer to conduct the demonstrations.
a) Submit requests for supplemental assistance and facilities with the Contractor’s proposed lesson plans.

3) Contractor remains responsible for equipment disassembly or assembly during hands-on training situations involving equipment disassembly or assembly by County’s personnel.

f. Training aids:
    1) Instructors shall provide needed audio-visual devices such equipment (televisions, video recorder/player, computer, projectors, screens, easels, etc.), models, charts, etc. for each class.
    2) Instructor to confirm with Engineer in advance of each class that the classroom will be appropriate for the types of audiovisual equipment to be employed.

10. Training sessions:
    a. Provide training sessions for equipment/system as specified in the individual equipment/system section.
    b. Include the following information in the agenda:
        1) Instructor name.
        2) Listing of subjects to be discussed.
        3) Time estimated for each subject.
        4) Allocation of time for County staff to ask questions and discuss the subject matter.
        5) List of documentation to be used or provided to support training.
    c. County may request that particular subjects be emphasized, and the agenda be adjusted to accommodate these requests.
    d. Digitally record audio and video of each training session.
        1) Include classroom and field instruction with question and answering periods.
        2) Engineer approval required for producer of video materials from one of the following options:
            a) Qualified, professional video production company or individual.
        3) Record in digital format and recording shall become property of the County with exclusive rights.
            a) No video recording agreements will be entered into by the County.
        4) Media:
            a) Video quality shall be 720p HD or greater in MPG, AVCHD, AVI, or MP4 format.
            b) Digital color video format.
            c) Provide audio portion of the composite CD sufficiently free from electrical interference and background noise to provide complete intelligibility of oral report.
            d) Identification: On each copy provide a label with the following information:
                (1) Name of training.
                (2) Date video was recorded.
            e) Display continuous running time.
            f) At start of each video recording, record training class name, date, instructor’s name.
            g) Provide audio quality that is not degraded during the recording of the field sessions due to background noise, space, distance or other factors.
        5) The Contractor shall provide a written release from all claims to the recorded training material produced, if required.
    e. Distribute copies of the agenda to each student at the beginning of each training class.
    f. Trainees will keep training materials and documentation after the session.

g. Distribute Training Evaluation Form following each training session.
    1) Training Evaluation Form is included in this Section.
    2) Return completed Training Evaluation Forms to County's designated training coordinator immediately after session is completed.
    3) Revise training sessions judged "Unsatisfactory" by a majority of attendees.
        a) Conduct training sessions again until a satisfactory rating is achieved.

11. Engineer approval of County Training is required.

## 1.08 START-UP PHASE

A. Overview of Start-Up Phase:
    1. General:
        a. Confirm reliability requirements.
        b. Confirm regulatory compliance.

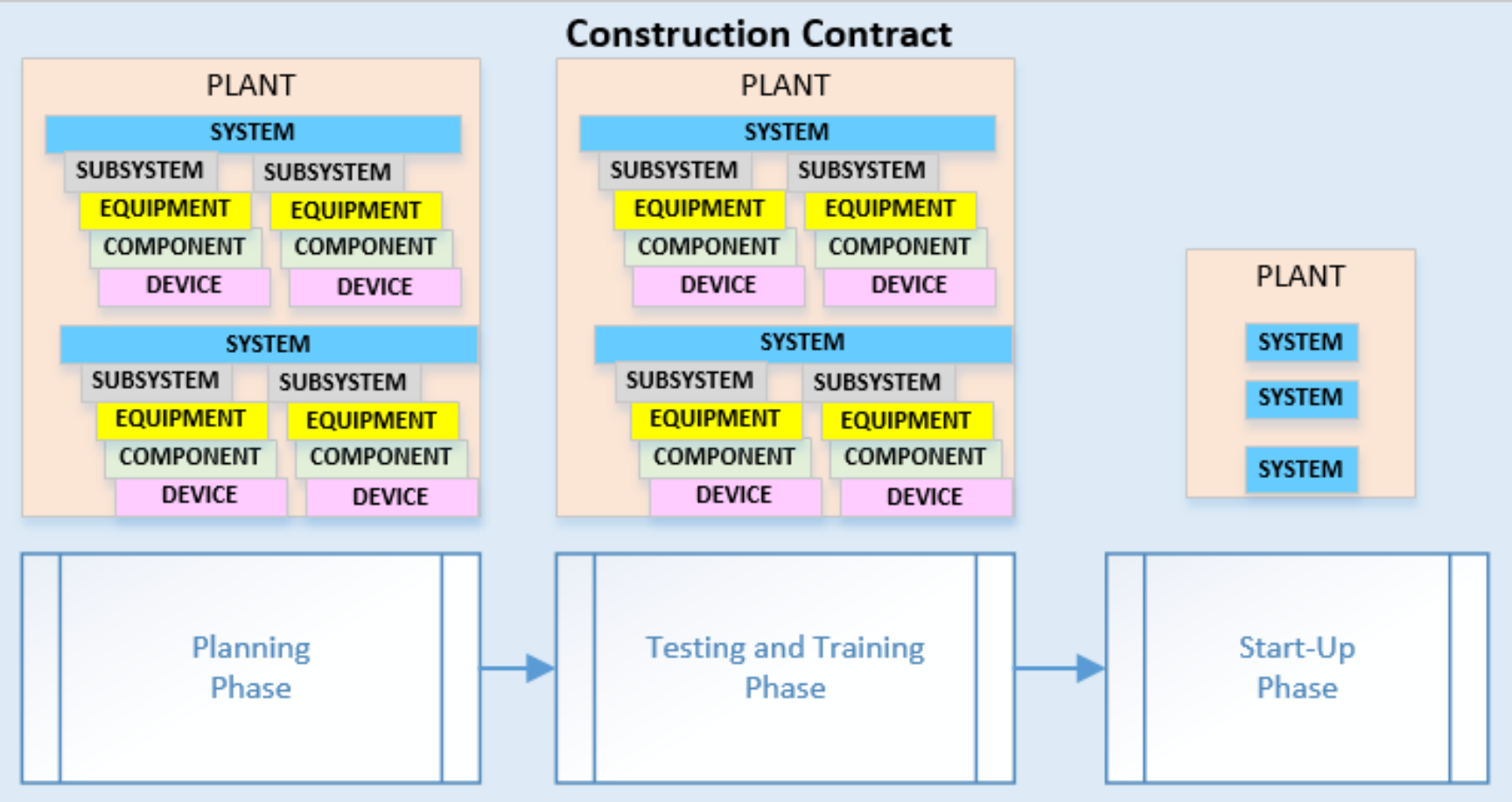
B. Start-Up Period:
    1. Contractor responsibilities:
        a. Support County to operate the Work.
    2. County responsibilities:
        a. County to operate the Work.
        b. County-provided services, equipment, and/or materials to be as specified in Section 01_11_00 - Summary of Work.
        c. Furnish labor, tools, equipment, instruments, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
    3. Prerequisites:
        a. Engineer approval of Testing and Training Phase.
    4. Witnessed.
    5. Duration: 7 days.
    6. Engineer approval of Start-Up Period is required to achieve substantial completion.

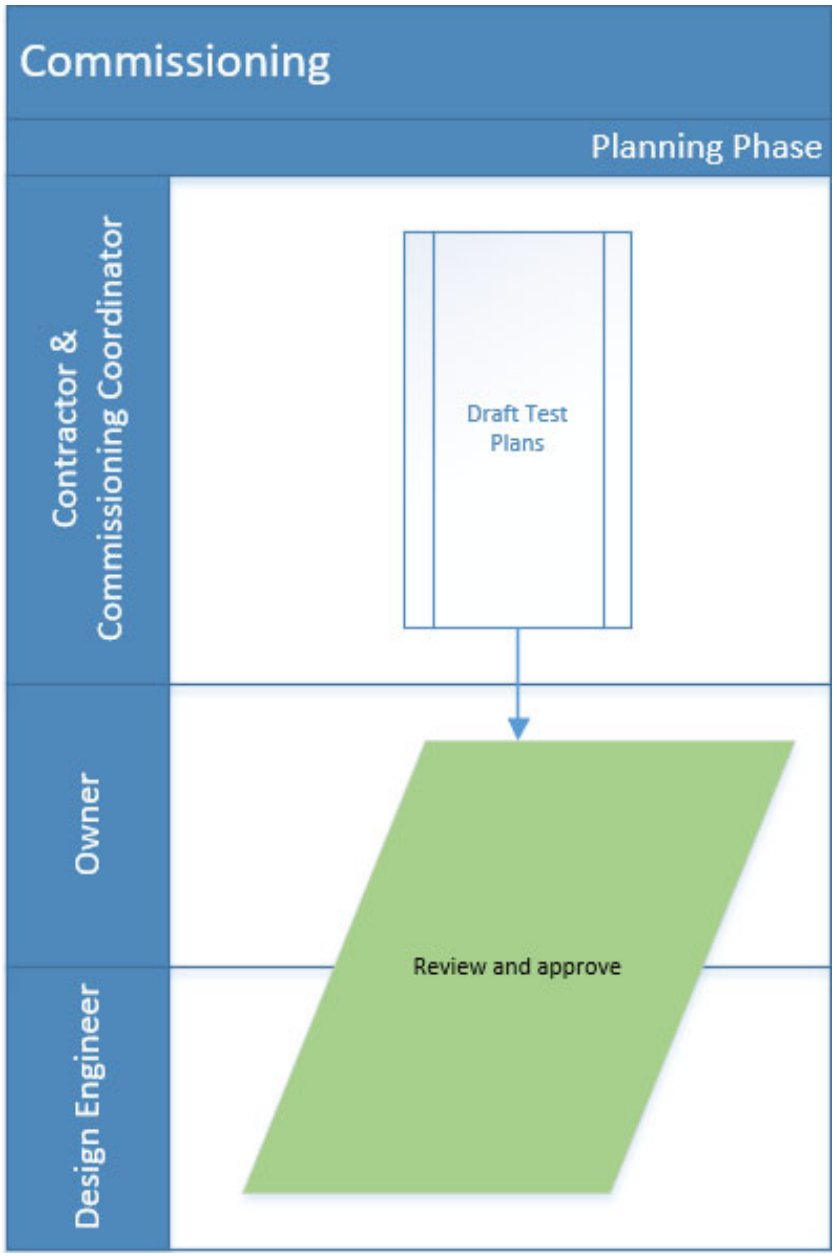
## PART 2 PRODUCTS (NOT USED)

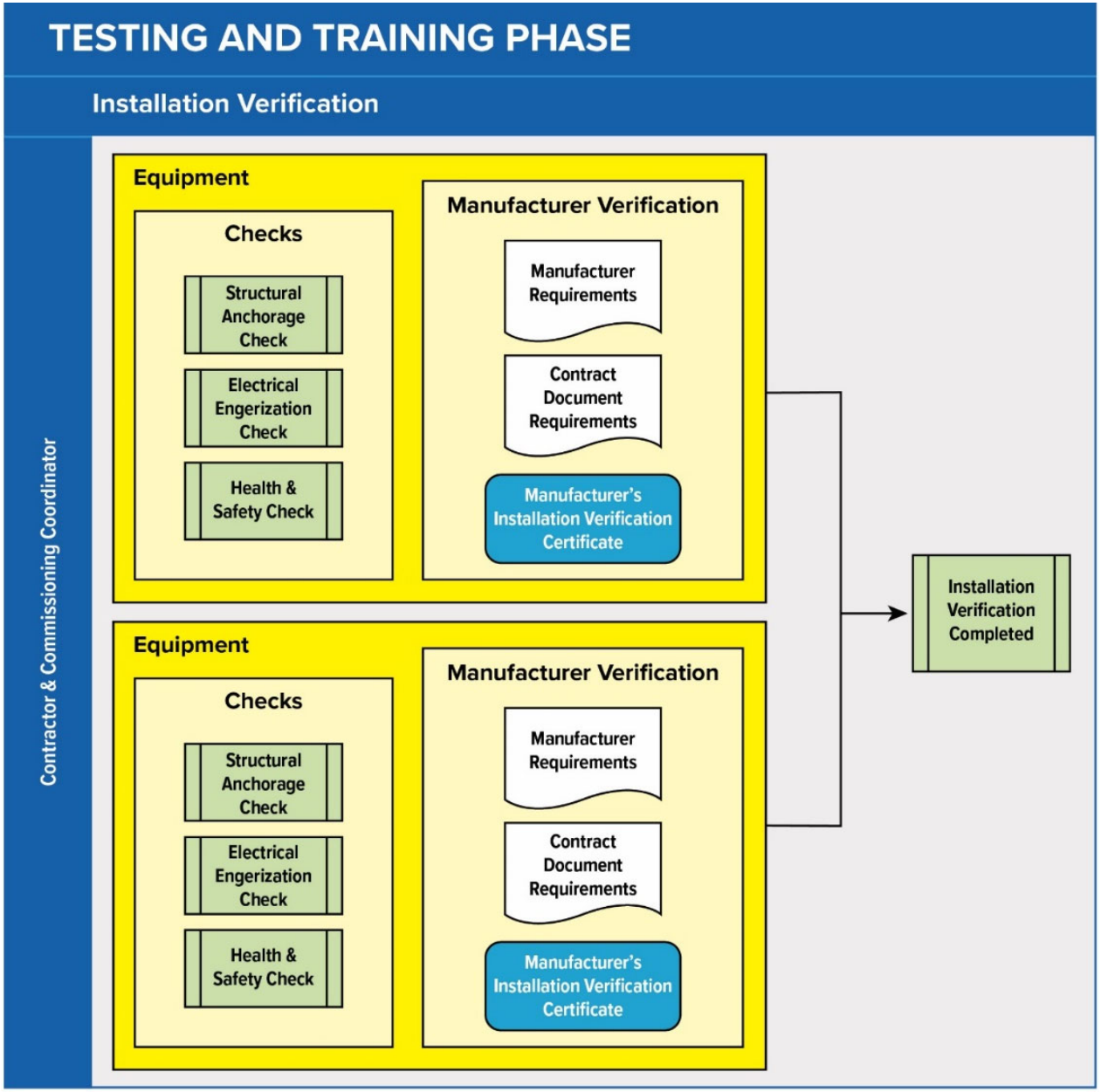
## PART 3 EXECUTION (NOT USED)

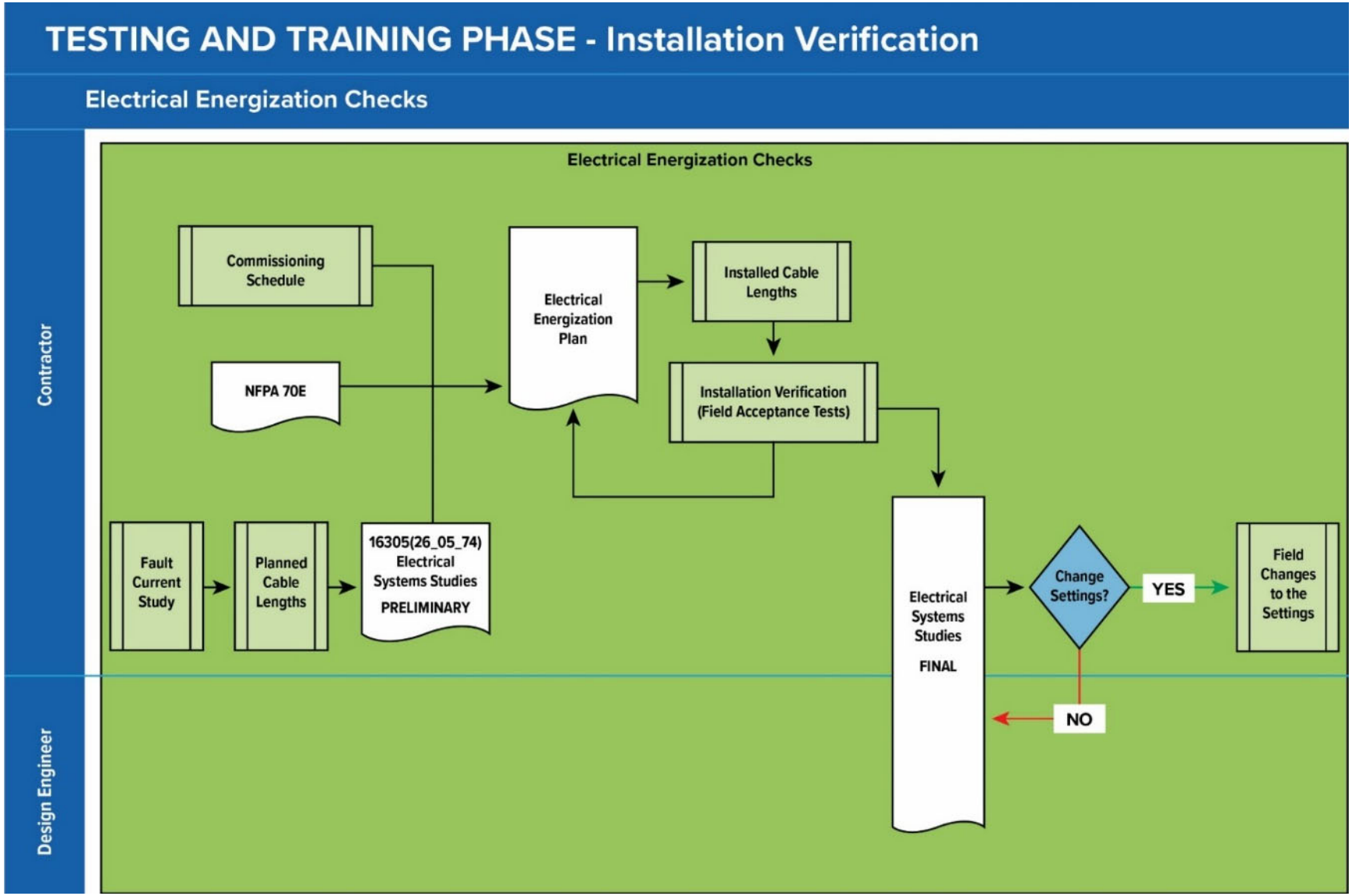
END OF SECTION

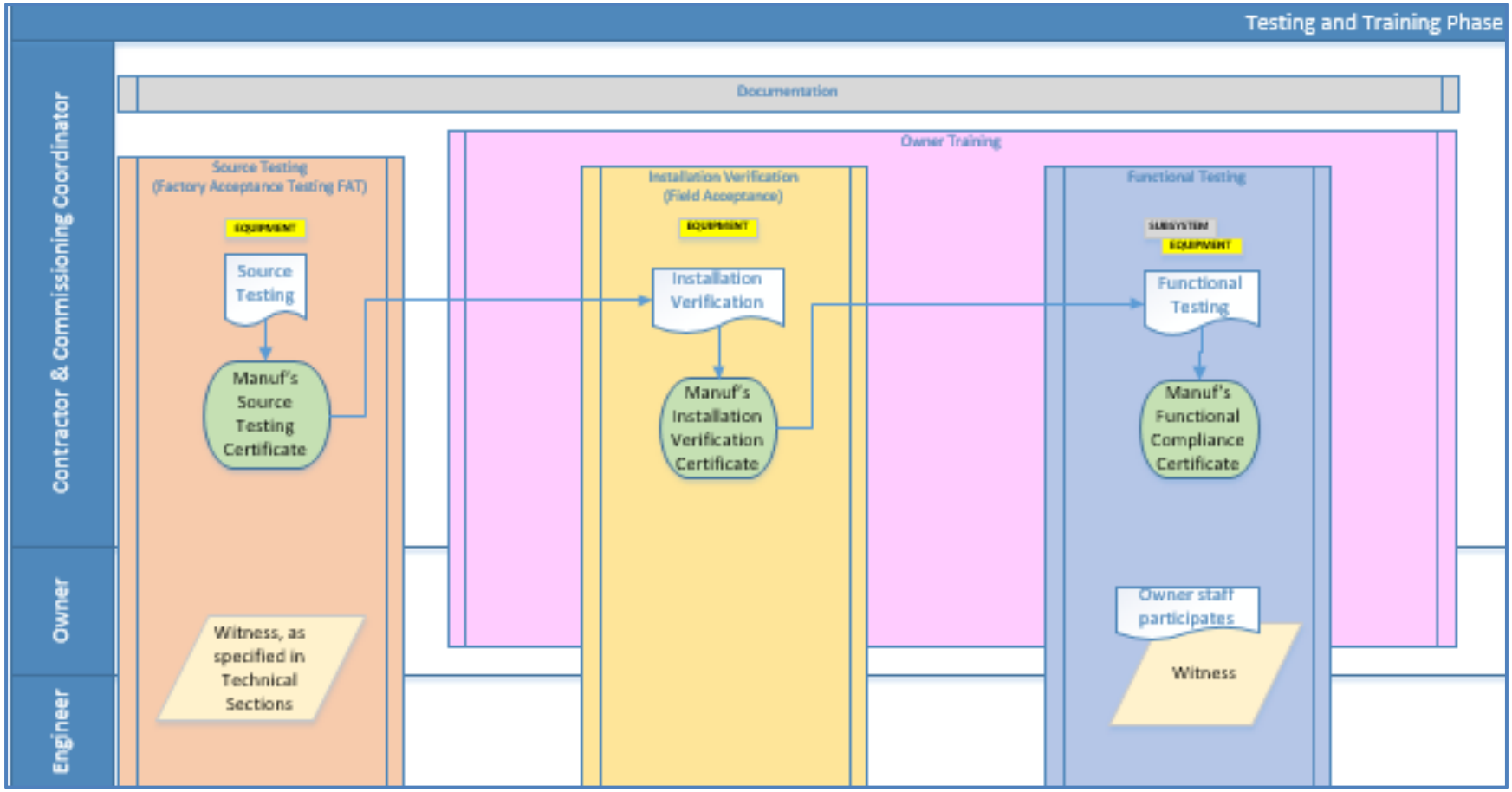
## ATTACHMENT A - COMMISSIONING FLOWCHARTS

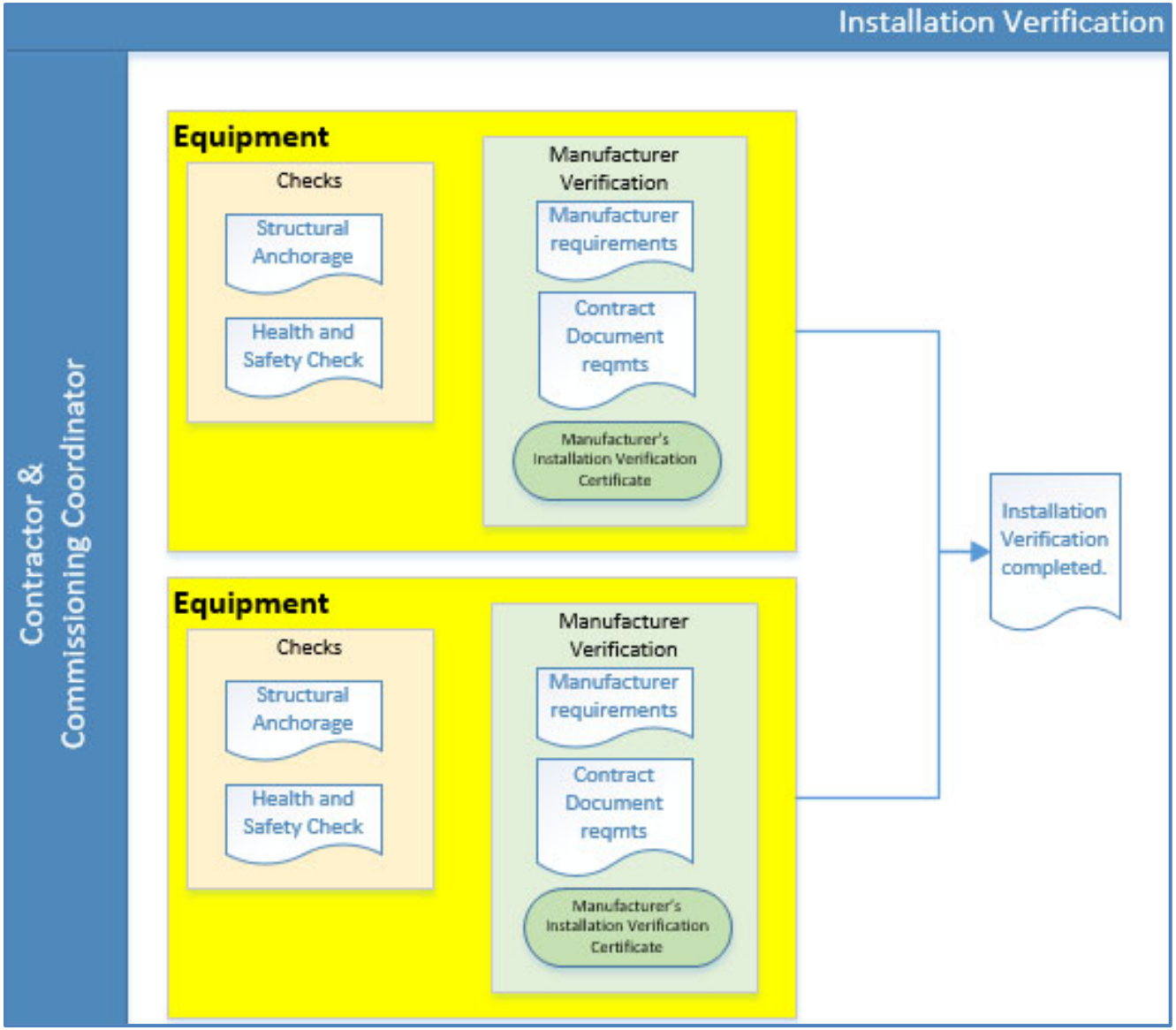

Construction Contract
PLANT
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
PLANT
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
PLANT
SYSTEM
SYSTEM
SYSTEM
Planning Phase
Testing and Training Phase
Start-Up Phase

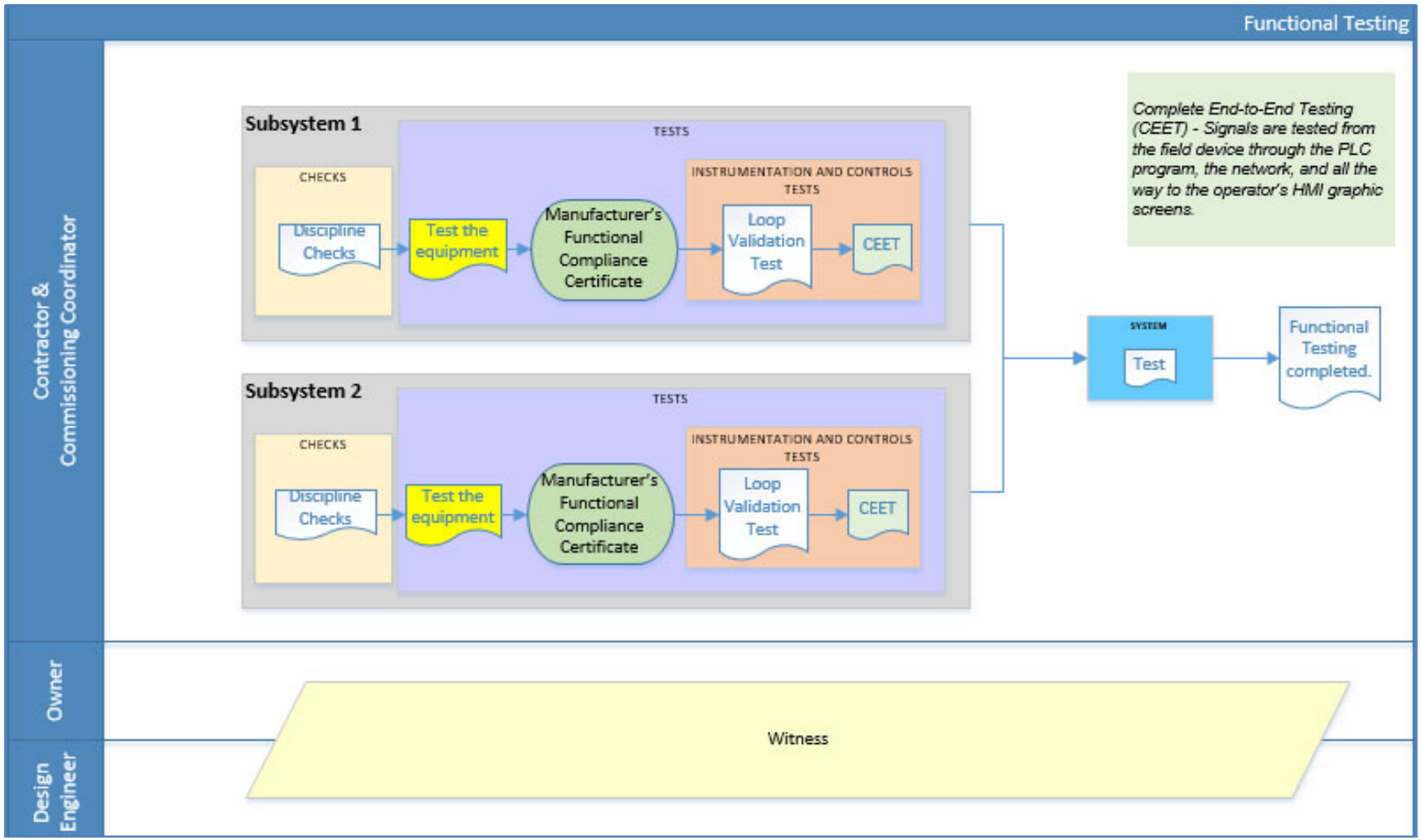

Commissioning
Planning Phase
Contractor & Commissioning Coordinator
Draft Test Plans
Owner
Review and approve
Design Engineer

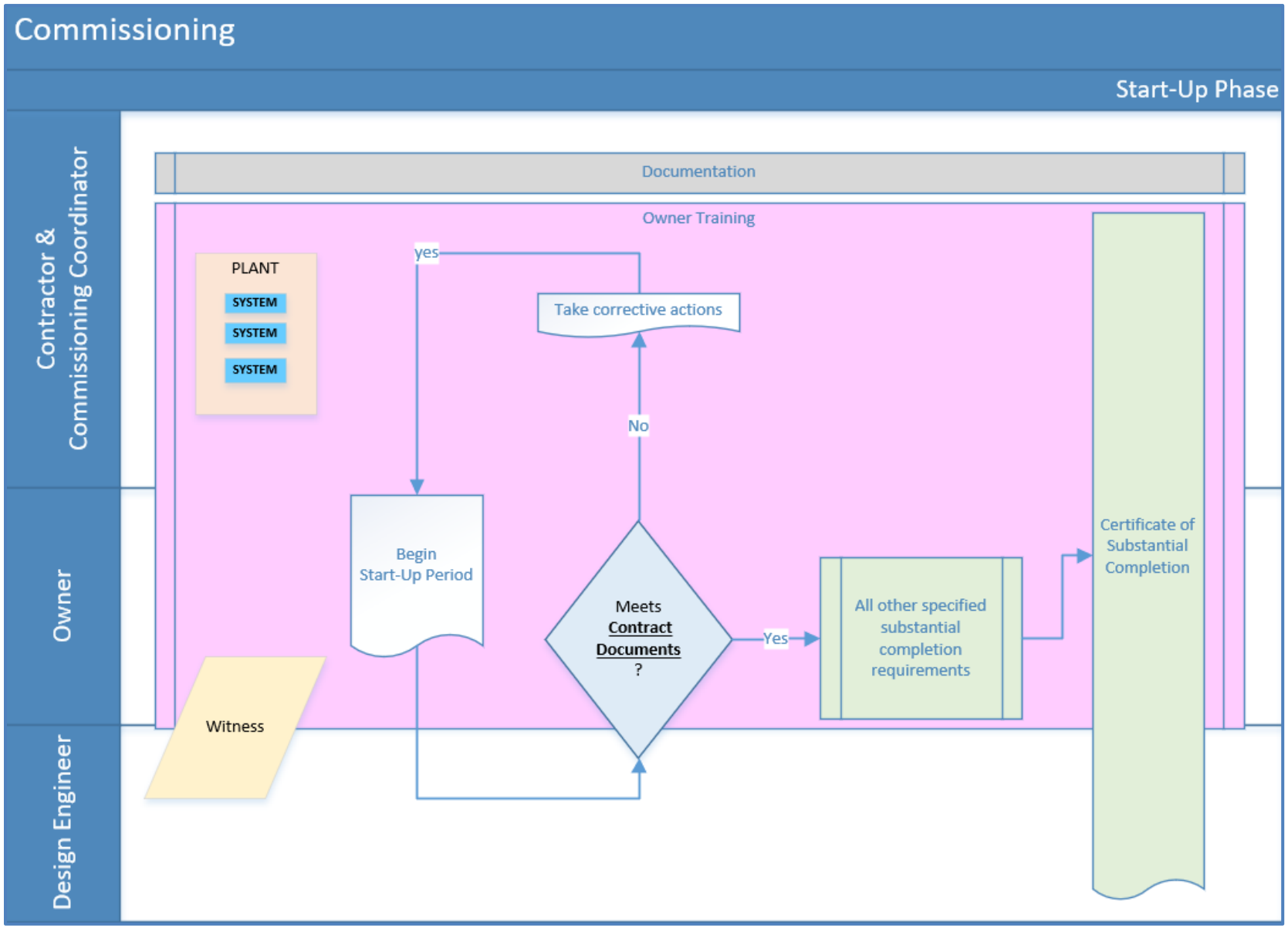

TESTING AND TRAINING PHASE
Installation Verification
Contractor & Commissioning Coordinator
Equipment
Checks
Structural Anchorage Check
Electrical Engerization Check
Health & Safety Check
Manufacturer Verification
Manufacturer Requirements
Contract Document Requirements
Manufacturer's Installation Verification Certificate
Equipment
Checks
Structural Anchorage Check
Electrical Engerization Check
Health & Safety Check
Manufacturer Verification
Manufacturer Requirements
Contract Document Requirements
Manufacturer's Installation Verification Certificate
Installation Verification Completed


TESTING AND TRAINING PHASE - Installation Verification
Electrical Energization Checks
Contractor
Design Engineer
Electrical Energization Checks
Commissioning Schedule
NFPA 70E
Electrical Energization Plan
Installed Cable Lengths
Installation Verification (Field Acceptance Tests)
Fault Current Study
Planned Cable Lengths
16305(26_05_74) Electrical Systems Studies PRELIMINARY
Electrical Systems Studies FINAL
Change Settings?
YES
NO
Field Changes to the Settings


Testing and Training Phase
Contractor & Commissioning Coordinator
Owner
Engineer
Documentation
Owner Training
Source Testing
(Factory Acceptance Testing FAT)
EQUIPMENT
Source Testing
Manuf's Source Testing Certificate
Witness, as specified in Technical Sections
Installation Verification
(Field Acceptance)
EQUIPMENT
Installation Verification
Manuf's Installation Verification Certificate
Functional Testing
SUBSYSTEM
EQUIPMENT
Functional Testing
Manuf's Functional Compliance Certificate
Owner staff participates
Witness


Installation Verification
Contractor & Commissioning Coordinator
Equipment
Checks
Structural Anchorage
Health and Safety Check
Manufacturer Verification
Manufacturer requirements
Contract Document reqmts
Manufacturer's Installation Verification Certificate
Equipment
Checks
Structural Anchorage
Health and Safety Check
Manufacturer Verification
Manufacturer requirements
Contract Document reqmts
Manufacturer's Installation Verification Certificate
Installation Verification completed.


Functional Testing
Contractor & Commissioning Coordinator
Owner
Design Engineer
Subsystem 1
TESTS
CHECKS
Discipline Checks
Test the equipment
Manufacturer's Functional Compliance Certificate
INSTRUMENTATION AND CONTROLS TESTS
Loop Validation Test
CEET
Subsystem 2
TESTS
CHECKS
Discipline Checks
Test the equipment
Manufacturer's Functional Compliance Certificate
INSTRUMENTATION AND CONTROLS TESTS
Loop Validation Test
CEET
Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
SYSTEM
Test
Functional Testing completed.
Witness


Commissioning
Start-Up Phase
Contractor & Commissioning Coordinator
Owner
Design Engineer
Documentation
Owner Training
PLANT
SYSTEM
SYSTEM
SYSTEM
yes
Take corrective actions
No
Begin Start-Up Period
Meets Contract Documents ?
Yes
All other specified substantial completion requirements
Certificate of Substantial Completion
Witness

## ATTACHMENT B - MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

## MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

COUNTY _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

Comments: _____

_____

_____

_____

_____

I hereby certify Source Testing has been performed on the above-referenced equipment/system as defined in the Contract, and results conform to the Contract Document requirements. Testing data is attached.

Date of Execution: _____, 20 _____

Manufacturer: _____

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

_____

(Authorized Signature)

If applicable, Witness Name *(print)*: _____

_____

(Witness Signature)

## ATTACHMENT C - MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

## MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

COUNTY _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

I hereby certify the installation of the above-referenced equipment/system as defined in the Contract Documents.

NOTES:

1. Attach written certification report prepared by and signed by the electrical and/or instrumentation subcontractor.

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 this equipment/system, and (iii) authorized to make recommendations required to ensure that the equipment/system 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: _____

Manufacturer: _____

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

By Manufacturer's Authorized Representative: _____

(Authorized Signature)

## ATTACHMENT D - MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

## MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

COUNTY _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

I hereby certify the Functional Testing of the above-referenced equipment/system as defined in the Contract Documents.

NOTES:

1. Attach test results with collected data and test report.
2. Attach written certification report prepared by and signed by the electrical and/or instrumentation subcontractor.

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 this equipment/system, and (iii) authorized to make recommendations required to ensure that the equipment/system 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: _____

Manufacturer: _____

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

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

WITNESSES:

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

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

## ATTACHMENT E - TRAINING EVALUATION FORM

## TRAINING EVALUATION FORM

EQUIPMENT/SYSTEM ITEM: _____

VENDOR/MANUFACTURER: _____

DATE: _____ NAME OF REPRESENTATIVE: _____

| | | | | | |
|---|---|---|---|---|---|
| 1. | Was representative prepared? | Acceptable | Unacceptable | or | N/A |
| 2. | Was an overview description presented? | Acceptable | Unacceptable | or | N/A |
| 3. | Were specific details presented for system components? | Acceptable | Unacceptable | or | N/A |
| 4. | Were alarm and shutdown conditions clearly presented? | Acceptable | Unacceptable | or | N/A |
| 5. | Were step-by-step procedures for starting, stopping, and troubleshooting presented? | Acceptable | Unacceptable | or | N/A |
| 6. | Were routine/preventative maintenance items clearly identified? | Acceptable | Unacceptable | or | N/A |
| 7. | Was the lubrication schedule (if any) discussed? | Acceptable | Unacceptable | or | N/A |
| 8. | Was the representative able to answer all questions? | Acceptable | Unacceptable | or | N/A |
| 9. | Did the representative agree to research and answer unanswered questions? | Acceptable | Unacceptable | or | N/A |
| 10. | Comments: _____ | | | | |
| 11. | Overall Rating | Satisfactory | Unsatisfactory | | |

Note:

Sessions judged “Unsatisfactory” by a majority of attendees shall be revised and conducted again until a satisfactory rating is achieved.

## ATTACHMENT F- COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

## COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

| NO. | TASK | COUNTY | CONTRACTOR | ENGINEER |
|---|---|---|---|---|
| **Testing and Training Phase** | | | | |
| **Source Testing** | | | | |
| | Source Testing | Non-Witnessed | Lead | Non-Witnessed Review |
| | Manufacturer's Certificate of Source Testing | No Action | Lead | Review |
| **Installation Verification** | | | | |
| | Structural Anchorage Check | Witness | Lead | Review |
| | Health and Safety Check | Witness | Lead | Review |
| | Manufacturer Requirements Verification | No Action | Lead | Review |
| | Contract Documents Verification | No Action | Lead | Review |
| | Manufacturer's Certificate of Installation Verification | No Action | Lead | Review |
| **Functional Testing** | | | | |
| | Checks | Witness | Lead | Witness, Review |
| | Tests | Witness | Lead | Witness, Review |
| | Manufacturer's Certificate of Functional Compliance | No Action | Lead | Witness, Review |
| **System Testing** | | | | |
| | System Testing | Witness | Lead | Witness, Review |
| **Start-Up Phase** | | | | |
| | Start-Up | Lead | Support | Witness, Review |

Legend:

**Lead:** Primarily responsible for organization, coordination, and execution of task work product or result.
**Support:** Assist the lead with organization, coordination, and execution of task work product or result.
**Witness:** Observe and document completion of task work product or result.
**No Action:** Limited or no involvement.
**Review:** Approve for compliance with Contract Documents or reject.

# ATTACHMENT G - FUNCTIONAL TESTING REQUIREMENTS

## FUNCTIONAL TESTING REQUIREMENTS

| System | Subsystem | Consecutive Day Test Duration (Days) | Significant Interruption Duration (Hours) | Test Liquid | System Operated By |
|---|---|---|---|---|---|
| SCRWTP Lime Slakers | Rotary valve, lime feeder, lime slaker, supply water panel, and grit remover. | 5 | 2 | Potable Water and quicklime | County under Direction of Contractor |
| SCRWTP Flow meters | Flow element and transmitter. | 2 | 2 | Potable Water | County under Direction of Contractor |
| NCRWTP Flow meter | Flow element and transmitter. | 2 | 2 | Potable Water | County under Direction of Contractor |

Notes:
(1) As specified in Section 01_11_00 - Summary of Work.
(2) As specified in this Section under Functional Testing.
(3) As specified in this Section under Functional Testing.

A. Schedule delays:
   1. Changes in the dates for Source Testing less than 30 days of the date provided in the latest approved Commissioning Schedule are considered delays.
   2. Contractor is responsible for associated costs resulting from delays:
      a. In person and/or virtual witnessing.
      b. Travel costs and witness labor costs.
         1) Witness labor costs at $250 per hour.

B. Repeat test costs:
   1. Contractor is responsible for associated costs for repeat testing:
      a. In person and/or virtual witnessing.
      b. Travel costs and witness labor costs.
         1) Witness labor costs at $250 per hour.

# SECTION 01_75_18

# DISINFECTION

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Cleaning and disinfection requirements for new and existing facilities affected by the Work.

### 1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C651 - Disinfecting Water Mains.
   2. C652 - Disinfection of Water Storage Facilities.
   3. C653 - Disinfection of Water Treatment Plants.
   4. C655 - Field Dechlorination.

B. U.S. Environmental Protection Agency (EPA):
   1. Method 524.2 Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry.
   2. Safe Drinking Water Act (SDWA).

### 1.03 SUBMITTALS

A. Submit disinfection test plan, which details procedure to be utilized to disinfect the facilities, including:
   1. Method and locations of disinfectant application.
   2. Locations of sampling points.
   3. Method of flushing and location of flushing ports (as appropriate for method of chlorination).
   4. Method of dechlorination (as appropriate for method of chlorination).
   5. Disposal location for chlorinated water (as appropriate for method of chlorination).

B. Submit disinfection reports and include the following:
   1. Date issued.
   2. Project name and location.
   3. Treatment subcontractor’s name, address, and phone number.
   4. Type and form of disinfectant used.
   5. Time and date of disinfectant injection start.
   6. Time and date of disinfectant injection completion.
   7. Test locations.
   8. Initial and 24-hour disinfectant residuals in milligrams per liter for each outlet tested.
   9. Time and date of flushing start.
   10. Time and date of flushing completion.

11. Disinfectant residual after flushing in milligrams per liter for each outlet tested.

C. Submit bacteriological reports and include the following:
   1. Date issued.
   2. Project name and location.
   3. Laboratory name, certification number, address, and phone number.
   4. Time and date of water sample collection.
   5. Name of person collecting samples.
   6. Test locations.
   7. Time and date of laboratory test start.
   8. Coliform bacteria test results for each outlet tested.
   9. Certification that water conforms or fails to conform to bacterial standards of SDWA.
   10. Bacteriologist's signature and bacteriological laboratory's evidence of certification.

D. Submit required permits, including, but not limited to, permit clearance.
   1. Coordinate with County and Engineer to obtain any necessary signatures.

## 1.04 QUALITY ASSURANCE

A. Bacteriological and physical chemistry laboratory: Certified by state in which Project is located.

## 1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Protect chlorine and bacteriological samples against damage and contamination.

B. Maintain caution labels on hazardous materials.

C. Maintain storage room dry and with temperatures as uniform as possible between 60 degrees Fahrenheit and 80 degrees Fahrenheit.

## 1.06 PROTECTION

A. Provide necessary signs, barricades, and notices to prevent persons from accidentally consuming water or disturbing system being treated.

# PART 2 PRODUCTS

## 2.01 MATERIALS

A. Disinfectant: Free chlorine in liquid, powder, tablet, or gas form in accordance with AWWA C653.

B. Dechlorination agent: Sulfur dioxide, sodium bisulfate, sodium sulfite, or sodium thiosulfate in accordance with AWWA C655.

## PART 3 EXECUTION

### 3.01 DISINFECTION OF WATER TREATMENT PLANTS

A. Perform disinfection of water treatment plants in accordance with AWWA C653 and as specified in this Section.

B. Complete hydrostatic/leakage tests prior to disinfection.

C. Clean newly constructed and/or modified facilities, including filters and conveyance facilities, such as pipes and channels at the plant, in accordance with AWWA C653 and the following:
   1. Remove debris and material not associated with the structure or process prior to disinfection.
   2. Clean wall, floor, ceiling, and attached surfaces by use of high-pressure water jet, sweeping, scrubbing, or equally effective means.
   3. Remove water, paint flakes, sediment, dirt, and foreign material accumulated during cleaning.
   4. Remove by flushing or other means, soil and debris from water pipes and channels in accordance with AWWA C651.
   5. Protect surfaces from adverse environmental exposure between the preliminary cleaning and the disinfection stages.

D. Prior to chlorination, clean newly constructed and/or modified facilities to be disinfected in accordance with AWWA C651, C652, or C653, as applicable.

E. Provide necessary blind flanges, hoses, sample taps, or any other appurtenances that may be required to clean and disinfect the piping and wetted surfaces.

F. System treatment:
   1. Start disinfection when conditions are satisfactory.
   2. Perform disinfection of water lines and structures in accordance with AWWA C651, C652, and C653, and as specified in this Section.
   3. Starting at outlet closest to water source, bleed water from each outlet until water produces odor of disinfectant. Repeat process at each outlet throughout system.
   4. Test for disinfectant residual at each of following locations and other locations in accordance with submitted disinfection test plan:
      a. Ends of piping runs.
      b. Remote outlets.
      c. Tanks.
      d. At least 2 outlets on each building floor where directed.
      e. Drain lines.
      f. Filters and effluent channels and piping.
   5. Maintain disinfectant in system for appropriate 6-hour or 24-hour interval in accordance with AWWA C652.
   6. When disinfectant residual is less than 10 milligrams per liter after 24 hours, repeat system treatment.

7. Stainless steel piping:
    a. Modify procedures for disinfection of stainless steel piping and appurtenances as necessary to avoid causing corrosion, pitting, or attack of stainless steel materials.
        1) Take steps to eliminate chlorinated water trapped in crevices and under gaskets through the following procedures:
            a) Pressurize stainless steel piping systems so that gaskets and O-rings are seated before introducing chlorinated water into the system.
            b) Flush to displace a minimum of 3 pipe volumes at the conclusion of the disinfection procedure.
    b. Use the continuous-feed method to fill the stainless steel piping system with the minimum chlorine concentration required to provide a 10 milligrams per liter residual after 24 hours of contact time in accordance with AWWA C651.

## 3.02 SURFACES TO BE DISINFECTED

A. Disinfect the following:
    1. Interior surfaces of the filters, basins, filter channels, etc., including the ceilings.
    2. Water storage reservoirs.
    3. Wetted surfaces associated with conveyance elements, such as pipes and channels downstream of the filters, basins.
    4. Any existing wetted surface downstream of the filters, basins that may have been contaminated during the construction process.
    5. Disinfect wetted surfaces, underdrain equipment, filter media, and submerged accessories associated with the filters:
        a. Disinfect the entire filter by chlorination.
        b. Allow a minimum of 24 hours for disinfection of a filter.
    6. After the filter sand layer has been brought to the specified gradation and thickness, disinfect each filter as follows:
        a. Inject sufficient chlorine into the washwater to produce a solution having a chlorine concentration of at least 25 milligrams per liter throughout the filter.
            1) Introduce sufficient washwater so that surfaces up to the maximum operating level of the filter will be in contact with the chlorinated water.
            2) Hold the chlorinated water for a minimum of 12 hours.
        b. As an alternative disinfection method, spray surfaces of the filter box up to the maximum operating level with a solution containing 200 milligrams per liter chlorine.
            1) Keep the solution in contact with the surfaces for a minimum 30 minutes.
            2) Disinfect the remaining portion of the filter with a 25 milligrams per liter chlorine solution for a minimum of 12 hours.
        c. Provide chlorine required for disinfection.
        d. Direct the chlorinated water from disinfection operations to the recycle basins or washwater ponds, as directed by the County or Engineer.
    7. Piping systems that are used to convey water, solutions, or chemicals to potable water facilities.

## 3.03 DISINFECTION OF WATER MAINS

A. Perform disinfection in accordance with AWWA C651 and as specified in this Section.

B. Cleaning:
   1. Remove, by flushing or other means, soil and debris from the water tanks in accordance with AWWA C652 prior to chlorination.

C. Inspection:
   1. Verify that water system is completed and cleaned of soil and debris prior to chlorination.

## 3.04 DISINFECTION OF WATER STORAGE FACILITIES

A. Perform disinfection in accordance with AWWA C652 and as specified in this Section.

B. Test for disinfectant residual at locations as specified in the disinfection test plan:
   1. Inlet and outlet piping.
   2. Drain line.

C. Maintain disinfectant in system for appropriate 6-hour or 24-hour interval in accordance with AWWA C652.

D. When disinfectant residual is less than 2 parts per million after 24 hours, repeat system treatment.

## 3.05 REPAIRS OR CONNECTIONS TO EXISTING LINES

A. Perform disinfection in accordance with AWWA C651 and as specified in this Section.

B. Clean and sterilize the interior surfaces of new piping, fittings, equipment, and appurtenances to be installed in an existing potable water system or connected to an existing system.

C. Clean and sterilize the existing pipe or facilities for a minimum distance of 3 pipe diameters back from the ends of the pipe. Plug the ends of the line when work is not being performed on the pipe.

D. Perform sterilization by swabbing each item with a concentrated chlorine solution.
   1. Each piece is to be disinfected prior to being assembled for installation in the existing pipe.
   2. Disinfect each piece just prior to assembly to help prevent recontamination.
   3. Plug the ends of the assembly until a new item is to be added to the assembly.
   4. Store disinfected materials on blocks to prevent contact with the ground.

## 3.06 FLUSHING

A. Remove disinfection water from the facilities as appropriate for the type of disinfectant and method used for disinfection.

B. Flush facilities with potable water containing no more disinfectant residual than the active distribution system or 1.0 milligrams per liter, whichever is greater (as appropriate for method of chlorination).

C. Continue flushing until water at designated flushing ports contains disinfectant residual equal to concentration specified above.

## 3.07 DISPOSAL OF CHLORINATED WATER

A. Dispose in accordance with AWWA C655 and as specified in this Section.

B. Dispose of chlorinated water in accordance with the submitted disinfection test plan and applicable requirements of federal, state, county, and city having jurisdiction over disposal of hazardous wastes in location of the Project and disposal site.

C. Chlorinated water may only be disposed of in a sanitary sewer system with the written permission of the County. If allowed, discharge the chlorinated water at a low rate so it does not surcharge the sewer line.

## 3.08 BACTERIOLOGICAL TEST

A. Instruct bacteriological laboratory to collect water samples no sooner than 24 hours after start of disinfection of each facility.

B. A minimum of 24 hours after flushing system and within 24 hours before the water main is placed in service, collect bacteriological quality samples at each of following locations and other locations in accordance with the submitted disinfection test plan and Standard Methods for the Examination of Water and Wastewater:
   1. Where water enters system.
   2. Inlet piping.
   3. Ends of piping runs.
   4. Drain lines.
   5. Remote outlets.
   6. Tanks.
   7. At least 2 outlets on each building floor.

C. Analyze water samples in accordance with Standard Methods for Examination of Water and Wastewater.

D. When bacteriological test proves water quality to be unacceptable, repeat disinfection treatment process until water meets quality standards for disinfection.

END OF SECTION

# SECTION 01_77_00

# CLOSEOUT PROCEDURES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Contract closeout requirements.

### 1.02 REFERENCES

A. American Water Works Association (AWWA).

### 1.03 FINAL CLEANING

A. Perform final cleaning prior to inspections for Final Completion.

B. Employ skilled workers who are experienced in cleaning operations.

C. Use cleaning materials which are recommended by manufacturers of surfaces to be cleaned.

D. Prevent scratching, discoloring, and otherwise damaging surfaces being cleaned.

E. Clean roofs, gutters, downspouts, and drainage systems.

F. Broom clean exterior paved surfaces and rake clean other surfaces of site work:
   1. Police yards and grounds to keep clean.

G. Remove dust, cobwebs, and traces of insects and dirt.

H. Clean grease, mastic, adhesives, dust, dirt, stains, fingerprints, paint, blemishes, sealants, plaster, concrete, and other foreign materials from sight-exposed surfaces, and fixtures and equipment.

I. Remove non-permanent protection and labels.

J. Polish waxed woodwork and finish hardware.

K. Wash tile.

L. Wax and buff hard floors, as applicable.

M. Wash and polish glass, inside and outside.

N. Wash and shine mirrors.

O. Polish glossy surfaces to clear shine.

P. Vacuum carpeted and soft surfaces.

Q. Clean permanent filters and replace disposable filters when heating, ventilation, and air conditioning units were operated during construction.

R. Clean ducts, blowers, and coils when units were operated without filters during construction.

S. Clean light fixtures and replace burned-out or dim lamps.

T. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

## 1.04 WASTE DISPOSAL

A. Arrange for and dispose of surplus materials, waste products, and debris off-site:
   1. Prior to making disposal on private property, obtain written permission from County of such property.

B. Do not fill ditches, washes, or drainage ways which may create drainage problems.

C. Do not create unsightly or unsanitary nuisances during disposal operations.

D. Maintain disposal site in safe condition and good appearance.

E. Complete leveling and cleanup prior to Final Completion of the Work.

## 1.05 TOUCH-UP AND REPAIR

A. Touch-up or repair finished surfaces on structures, equipment, fixtures, and installations that have been damaged prior to inspection for Substantial Completion.

B. Refinish or replace entire surfaces which cannot be touched-up or repaired satisfactorily.

## 1.06 FINAL CLEANING AND DISINFECTION OF SYSTEMS OF PLANT FACILITIES

A. Clean channels, pipe, basins, reservoirs, and tanks before running of 7-day test, or before facility goes on stream when 7-day test is not required

B. Wash, wherever practicable, or broom sweep channels, pipe, basins, reservoirs, and tanks.

C. Disinfect filter basins, reservoirs, clear wells, tanks, channels, and piping intended to carry potable water as follows or in accordance with AWWA Standards.

D. Provide ample sampling outlets in pipe for testing.

E. Fill pipe and other plant facilities with chlorine solution of sufficient strength to retain residual of not less than 10 parts per million at end of 24 hours.

F. When reservoirs and basins are too large to be economically disinfected by filling with chlorine solution, spray reservoirs and basins with solution containing 100 parts per million of chlorine.

G. After disinfection, rinse entire potable water system with potable water sufficient to reduce chlorine residual to not more than 0.6 parts per million throughout system before system is put into service.

## 1.07 FINAL CLEANING AND DISINFECTION OF SYSTEMS OF POTABLE WATER MAINS

A. Clean interior of pipe and fittings.

B. When pipe contains dirt that cannot be removed by flushing, swab pipe interiors with solution containing not less than 500 parts per million of chlorine until clean.

C. Flush 12-inch in diameter and smaller pipe as thoroughly as available water sources will permit.

D. Fill pipe with chlorine solution of sufficient strength to provide 10 parts per million chlorine residual at end of 24 hours.

E. Flush pipes with potable water until chlorine residual is less than 0.6 parts per million before pipe are put into service.

## 1.08 CLOSEOUT DOCUMENTS

A. Submit the following Closeout Submittals before Substantial Completion:
   1. Punch list of items to be completed or corrected with the request for issuance of Substantial Completion.
   2. Evidence of Compliance with Requirements of Governing Authorities.
   3. Project Record Documents.
   4. Approved Operation and Maintenance Manuals.
   5. Approved Warranties and Bonds.
   6. Keys and Keying Schedule.
   7. Completed contract requirements for commissioning and process start-up.

B. Submit the following Closeout Submittals before final completion of the Work and at least 7 days prior to submitting Application for Final Payment:
   1. Punch list of items have been completed and Engineer and County are satisfied that all deficiencies are corrected.
   2. Evidence of Payment and Release of Liens or Stop Payment Notices as outlined in Conditions of the Contract.
   3. Release of claims as outlined in Conditions of the Contract.
   4. Submit certification of insurance for products and completed operations, as specified in the General Conditions.
   5. Final statement of accounting.
   6. Submit Final (As-Built) Schedule as specified in Section 01_32_21 - Schedules and Reports.

## 1.09 EVIDENCE OF COMPLIANCE WITH REQUIREMENTS OF GOVERNING AUTHORITIES

A. Submit the following:
   1. Certificate of Occupancy.
   2. Certificates of Inspection:
      a. Mechanical:
      b. Electrical:

## 1.10 PROJECT RECORD DOCUMENTS

A. Maintain at Project site, available to County and Engineer, 1 copy of the Contract Documents, shop drawings, and other submittals in good order:
   1. Mark and record field changes and detailed information contained in submittals and change orders.
   2. Record actual depths, horizontal and vertical location of underground pipes, duct banks, and other buried utilities. Reference dimensions to permanent surface features.
   3. Identify specific details of pipe connections, location of existing buried features located during excavation, and the final locations of piping, equipment, electrical conduits, manholes, and pull boxes.
   4. Identify location of spare conduits including beginning, ending, and routing through pull boxes and manholes. Record spare conductors, including number and size, within spare conduits and filled conduits.
   5. Provide schedules, lists, layout drawings, and wiring diagrams.
   6. Make annotations in electronic format. conforming to the following color code:

| | |
|---|---|
| Additions: | Red |
| Deletions: | Green |
| Comments | Blue |
| Dimensions: | Graphite |

B. Maintain documents separate from those used for construction:
   1. Label documents "RECORD DOCUMENTS."

C. Keep documents current:
   1. Record required information at the time the material and equipment is installed and before permanently concealing.
   2. Engineer will review Record Documents weekly to ascertain that changes have been recorded.

D. Affix civil engineer's or professional land surveyor's signature and registration number to Record Drawings to certify accuracy of information shown.

E. Deliver Record Documents with transmittal letter containing date, Project title, Contractor's name and address, list of documents, and signature of Contractor.

F. Record Documents will be reviewed monthly to determine the percent complete for the monthly pay application.

G. Updated Record Documents are a condition for Engineer's recommendation for progress payment.

H. Final Schedule Submittal as specified in Section (01_32_21) - Schedules and Reports.

## 1.11 MAINTENANCE SERVICE

A. Maintenance service as specified in technical specifications.

## 1.12 SUBSTANTIAL COMPLETION

A. Obtain Certificate of Substantial Completion.

## 1.13 FINAL COMPLETION

A. When Contractor considers the Work is complete, submit written certification that:
   1. Work has been completed in accordance with the Contract Documents:
   2. Punch list items have been completed or corrected.
   3. Work is ready for final inspection.

B. Engineer will make an inspection to verify the status of completion with reasonable promptness.

C. Should the Engineer consider that the Work is incomplete or defective:
   1. Engineer will promptly notify the Contractor in writing, listing the incomplete or defective work.
   2. Contractor shall take immediate steps to remedy the stated deficiencies and send a second written certification to the Engineer that the Work is complete.
   3. Engineer shall re-inspect the Work.

## 1.14 FINAL ADJUSTMENT OF ACCOUNTS

A. Submit a final statement of accounting to the Engineer at least 7 days prior to final Application for Payment.

B. Statement shall reflect all adjustments to the Contract amount.
   1. The original Contract amount.
   2. Additions and deductions resulting from:
      a. Change Orders.
      b. Units installed and unit prices.
      c. Set-offs for uncorrected or incomplete Work.
      d. Set-offs for liquidated damages.
      e. Set-offs for reinspection payments.
      f. Extended engineering and/or inspection services and inspection overtime.
      g. Excessive shop drawings review cost by the Engineer.
      h. Other adjustments.
   3. Total Contract amount, as adjusted.
   4. Previous payments.
   5. Remaining payment due.

C. Engineer will prepare a final Change Order reflecting approved adjustments to the Contract amount which were not previously made by Change Orders.

## 1.15 FINAL APPLICATION FOR PAYMENT

A. Contractor shall submit the final Application for Payment reflecting the agreed upon information provided in the final statement of accounting.

# PART 2 PRODUCTS

## 2.01 SPARE PARTS

A. County may request advanced delivery of spare parts, maintenance products, and special tools.
   1. Deduct the delivered items from the inventory list and provide transmittal documentation.

B. Prior to Substantial Completion, arrange to deliver spare parts, maintenance products, and special tools to County at a location on site chosen by the County.
   1. Provide itemized list of spare parts and special tools that matches the identification tag attached to each item.
   2. County and Engineer will review the inventory and the itemized list to confirm it is complete and in good condition prior to signing for acceptance.

# PART 3 EXECUTION (NOT USED)

END OF SECTION

## SECTION 01_78_24

## OPERATION AND MAINTENANCE MANUALS

### PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Preparation and submittal of manual with requirements to operate and maintain the equipment.

### 1.02 PREPARATION

A. General requirements:
   1. Provide dimensions in English units.
   2. Assemble material, where possible, in the same order within each volume.
   3. Reduce drawings and diagrams to 8 1/2 by 11-inch size, if possible unless otherwise specified.
   4. Complete forms on computer, handwriting not acceptable.
   5. Delete items or options not provided in the supplied equipment or system.
   6. Provide package control system annotated ladder logic for PLC, if applicable.

B. Hard copy requirements:
   1. Binders: 3-ring with rigid covers.
      a. Break into separate binders as needed to accommodate large size.
   2. Utilize numbered tab sheets to organize information.
   3. Provide original and clear text on reproducible non-colored paper, 8 1/2 by 11-inch size, 24 pound paper.
   4. Drawings larger than 8 1/2 by 11 inch:
      a. Fold drawings separately and place in envelope bound into the manual.
      b. Label each drawing envelope on the outside regarding contents.

C. Electronic requirements:
   1. File format:
      a. Entire manual in PDF format.
         1) Include text and drawing information.
         2) Provide a single PDF file even if the hard copy version is broken into separate binders due to being large.
         3) Create PDF from the native format of the document (Microsoft Word, graphics programs, drawing programs, etc.).
            a) If material is not available in native format and only available in paper format, remove smudges, fingerprints, and other extraneous marks before scanning to PDF format.
            b) Hard copy record drawing requirements:
               (1) Provide a single multipage PDF file of each set of the scanned drawings.
               (2) Page 1 shall be the cover of the drawing set.

c) At file opening, display the entire cover.
(1) Scan drawings at 200 to 300 dots per inch (DPI), black and white, Group IV Compression, unless otherwise specified.
(2) Scan drawings with photos in the background at 400 dots per inch (DPI), black and white, Group IV Compression.
4) Pagination and appearance to match hard copy.
5) Searchable.
6) Scanned images are not acceptable.
7) Bookmarks:
a) Bookmarks shall match the table of contents.
b) Bookmark each section (tab) and heading.
c) Drawings: Bookmark at a minimum, each discipline, area designation, or appropriate division.
d) At file opening, display all levels of bookmarks as expanded.
8) Thumbnails optimized for fast web viewing.
b. Drawing requirements:
1) Provide additional copy of drawings in most current version of AutoCAD format.
2) Drawings shall have a white background.
3) Drawing shapes shall not degrade when closely zoomed.
4) Screening effects intended to de-emphasize detail in a drawing must be preserved.
5) Delete items or options not provided in the supplied equipment or system.
2. Media:
a. USB flash drive.
b. Secure File Transfer Protocol (SFTP).
3. Label media with the following information:
a. Operation and Maintenance Manual.
b. Equipment name.
c. Specification Section Number
d. Equipment tag number.
e. County's name.
f. Project number and name.
g. Date.
4. If multiple submittals are made together, each submittal must have its own subdirectory that is named and numbered based on the submittal number.

## 1.03 CONTENTS

A. Table of Contents: General description of information provided within each tab section.

B. Complete Attachment A - Equipment Summary Form.

C. Description of system and components.

D. Description of equipment function, normal operating characteristics, and limiting conditions.

E. On-line resources.

F. Telephone resources.

G. Approved submittals.
   1. Markup with any field changes.
   2. Final programming.

H. Start-up procedures: Recommendations for installation, adjustment, calibration, and troubleshooting.

I. Operating procedures:
   1. Step-by-step instructions including but not limited to the following:
      a. Safety precautions and applicable Safety Data Sheets.
      b. Guidelines.
      c. Other information as needed for safe system operation and maintenance.

J. Preventative maintenance procedures:
   1. Recommended steps and schedules for maintaining equipment.
   2. Troubleshooting.

K. Lubrication information: Required lubricants and lubrication schedules.

L. Overhaul instructions: Directions for disassembly, inspection, repair and reassembly of the equipment; safety precautions; and recommended tolerances, critical bolt torques, and special tools that are required.

M. Manufacturer's technical reference manuals.

N. Source (factory) Test results: Provide copies of Source Tests reports as specified in technical sections.

O. Functional Test results: After Functional Tests are completed, insert Functional Test reports as specified in technical sections.

## 1.04 ARCHIVAL DOCUMENTATION

A. Typically does not require updating to remain valid and should be stored in a format that preserves the document and limits one's ability to make changes.

B. Types of archival documents include the following:
   1. Record drawings.
   2. Reports.
   3. Specifications.
   4. Shop drawings.
   5. Vendor Equipment O & M Manuals.
   6. Photos.
   7. Demonstration and training videos.
   8. Other.

## 1.05 LIVING DOCUMENTATION

A. Requires periodic updates to remain valid and should be stored in formats that are easy to update.

B. Types of living documents include the following:
   1. Facility O&M Manuals.
   2. Standard Operating Procedures.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## ATTACHMENT A - EQUIPMENT SUMMARY FORM

## EQUIPMENT SUMMARY FORM

1. EQUIPMENT ITEM _____

2. MANUFACTURER _____

3. EQUIPMENT TAG NUMBER(S) _____

4. LOCATION OF EQUIPMENT _____

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

_____

_____

_____

6. NAMEPLATE DATA -
   - Horsepower _____
   - Amperage _____
   - Voltage _____
   - Service Factor (S.F.) _____
   - Speed _____
   - ENC Type _____
   - Capacity _____
   - Other _____

7. MANUFACTURER'S LOCAL REPRESENTATIVE

   Name _____

   Address _____

   Telephone Number _____

8. MAINTENANCE REQUIREMENTS:

| Maintenance Operation | Frequency | Lubricant (if applicable) | Comments |
|---|---|---|---|
| (List each operation required. Refer to specific information in Manufacturer's Manual, if applicable) | (List required frequency of each maintenance operation) | (Refer by symbol to lubricant list as required) | |
| | | | |
| | | | |

9. LUBRICANT LIST:

| Reference Symbol | Conoco Phillips | Exxon/Mobil | BP/Amoco | Other (List) |
|---|---|---|---|---|
| (Symbols used in Item 7 above) | (List equivalent lubricants, as distributed by each manufacturer for the specific use recommended) | | | |
| | | | | |
| | | | | |
| | | | | |

10. SPARE PARTS (recommendations)_____

_____

11. COMMENTS_____

12. GENERAL INFORMATION:

Date Accepted*: _____

Expected Life*: _____

Project Name & Number: _____

Design Engineer: _____

13. WARRANTY:

Start Date: _____

Expiration Date: _____

Prorated: _____

# SECTION 01_81_50

# DESIGN CRITERIA

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Design criteria for use in the selection of equipment and appurtenances specified in Technical Sections of these Specifications and indicated on the Drawings.
   2. Criteria for design of systems, components and equipment fabricated off site and shipped to the Work for installation.
   3. Criteria for design of anchors to connect equipment and appurtenances to supports and structures.

B. The criteria in this Section apply throughout the Work, unless additional criteria, or more restrictive criteria, are indicated.
   1. Additional criteria and requirements relevant to specific locations, specific materials, and specific equipment are indicated on the Drawings, and in the Technical Sections.

### 1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):

B. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
   1. ASHRAE Fundamentals Handbook.

C. International Code Council (ICC):
   1. International Energy Conservation Code (IECC).
   2. International Plumbing Code (IPC).

D. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):
   1. Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd edition 2008.

### 1.03 PROJECT DESIGN CRITERIA

A. Site name: South County Regional Water Treatment Plant
   1. Street Address: As specified in Section 01_11_00 - Summary of Work.
   2. Site elevation:
      a. Approximately 10 feet above mean sea level.

A. All equipment and materials for the project are to be suitable for performance in domestic water treatment plant environment and under following conditions:
   1. Design temperatures are:
      a. Outdoor temperatures: 40 to 100 degrees Fahrenheit.

b. Indoor temperatures for the following buildings:
    1) Process areas: 55 to 95 degrees Fahrenheit.
    2) Electrical rooms: 55 to 85 degrees Fahrenheit.
2. Moisture conditions:
    a. Outdoor relative humidity: 40 to 90 percent.
    b. Indoor relative humidity: 40 to 60 percent.
    c. Other areas: as defined in individual equipment sections.
3. Other: Materials and equipment furnished shall be suitable for use outdoors in a humid subtropical climate.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 03_21_17

# ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Bonding reinforcing bars and all thread rods in concrete using adhesives.

### 1.02 REFERENCES

A. American Concrete Institute (ACI).
   1. 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.

B. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

C. ASTM international (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

D. Concrete Reinforcing Steel Institute (CRSI).

E. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

F. Society for Protective Coatings (SSPC):
   1. SP-1 - Solvent Cleaning.

### 1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Evaluation Service Report (ESR): Report prepared by ICC-ES, or other testing agency acceptable to Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and to document its acceptance for use under the building code specified in Section 01_41_00 - Regulatory Requirements.

### 1.04 SUBMITTALS

A. Product data: Technical data for adhesives, including:
   1. Manufacturer’s printed installation instructions (MPII).

2. Independent laboratory test results indicating allowable loads in tension and shear for concrete of the types included in this Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
3. Handling and storage instructions.

B. Quality control Submittals:
1. Special inspection: Detailed step-by-step instructions for the special inspection procedures required by the building code specified in Section 01_41_00 - Regulatory Requirements.
2. For each adhesive to be used, Evaluation Report confirming that the product complies with the requirements of AC308 for both un-cracked and cracked concrete and for use in Seismic Design Categories A through F.
3. Installer qualifications:
   a. Submit evidence of successful completion of adhesive manufacturer's installation training program.
   b. Submit evidence of current certification for installation of inclined and overhead anchors under sustained tension loading.

C. Inspection and testing reports:
1. Inspections: Field quality control: Reports of inspections and tests.
   a. Inspections: Field quality assurance: Reports of special inspections and tests.

## 1.05 QUALITY ASSURANCE

A. Qualifications:
1. Installation requirements:
   a. Have available at the site, and install anchors in accordance with, the adhesive manufacturer's printed installation instructions.
2. Installer qualifications:
   a. Demonstrating successful completion of adhesive manufacturer's on-site training program for installation of adhesive-bonded anchors.
   b. Holding current certification for installation of adhesive-bonded anchors by a qualified organization acceptable to the Engineer and to the Building Official.
      1) Organizations/certification programs deemed to be qualified are:
         a) ACI-CRSI Adhesive Anchor Installer Certification Program.
         b) Adhesive anchor manufacturer's certification program, subject to acceptance by the Engineer and the Building Official.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products as follows, unless more restrictive requirements are recommended by the manufacturer:
1. Store adhesives and adhesive components on pallets or shelving in a covered-storage area protected from weather.
2. Control temperature to maintain storage within manufacturer's recommended temperature range.
   a. If products have been stored at temperatures outside manufacturer's recommended range, test by methods acceptable to the Engineer to confirm acceptability before installing in the Work.

3. Dispose of products that have passed their expiration date.

## 1.07 PROJECT CONDITIONS

A. As specified in Section 01_81_50 - Design Criteria.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

B. Adhesives shall have a current Evaluation Report documenting testing and compliance with the requirements of ACI 355.4 and ICC-ES AC308 for use with un-cracked concrete and with cracked concrete in the Seismic Design Category specified.

C. Bond reinforcing bars and all thread rods in concrete using epoxy adhesive unless other adhesives specified are specifically indicated on the Drawings or approved in writing by the Engineer.

## 2.02 EPOXY ADHESIVE

A. Materials:
   1. Meeting the physical requirements of ASTM C881, Type IV, Grade 3, Class B or C depending on site conditions.
   2. 2-component, 100 percent solids, insensitive to moisture.
   3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

B. Packaging:
   1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer’s static mixing nozzle.
      a. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
      b. Provide nozzle extensions as required to allow full-depth insertion and filing from the bottom of the hole.
   2. 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.

C. Manufacturers: One of the following or equal:
   1. Hilti, Inc., HIT-RE 500-V3.
   2. Simpson Strong-Tie Co., Inc., SET-XP.

## 2.03 ACRYLIC AND HYBRID ADHESIVE

A. Materials:
   1. 2-component, high-solids, acrylic-based or hybrid acrylic and epoxy-based adhesive.
   2. Approved by the manufacturer for installation at substrate temperatures of 0 degrees Fahrenheit and above.

B. Packaging:
   1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
   2. 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.

C. Manufacturers: One of the following or equal:
   1. Hilti, Inc., HIT-HY-200.
   2. Simpson Strong-Tie Co., Inc., AT-XP.

## 2.04 ALL THREAD RODS

A. Materials: As specified in Section 05_12_00 - Structural Steel Framing for rods, nuts and washers.

## 2.05 REINFORCING BARS

A. As specified in Section 03_30_01 - Concrete Work.

# PART 3 EXECUTION

## 3.01 GENERAL

A. Execution of this work is restricted to installers who have personally completed the adhesive manufacturer's on-site training for the products to be installed, and who are personally certified through a qualified certification program described under Quality Assurance and accepted by the Engineer and the Building Official.
   1. Do not install holes or adhesive until training is complete.

B. Perform work in strict compliance with the accepted MPII and the following instructions. Where the accepted MPII and the instructions conflict, the MPII shall prevail.

C. Install reinforcing bars and all thread rods to embedment depth, and at spacing and locations indicated on the Drawings.
   1. If embedment depth is not indicated, contact the Engineer for requirements.

2. Do not install adhesive-bonded all thread rods or reinforcing bars in upwardly inclined or overhead applications unless accepted in advance by the Engineer.

## 3.02 PREPARATION

A. Do not begin installation of adhesive bonded anchors until:
   1. Concrete has achieved an age of at least 21 days after placement.
   2. On-site training in installation of adhesive bonded anchors by manufacturer's technical representative is complete. Do not drill holes in concrete or install adhesive and embeds in holes.

B. Review manufacturer's printed installation instructions (MPII) and "Conditions of Use" stipulated in the Evaluation Report before beginning work.
   1. Bring to the attention of the adhesive manufacturer's technical representative any discrepancies between these documents and resolve before proceeding with installation.

C. Install adhesive bonded anchors in full compliance with manufacturer's printed installation instructions using personnel who have successfully completed manufacturer's on-site training for products to be used and who hold certifications specified in this Section.

D. Confirm that adhesive and substrate receiving adhesive are within manufacturer's recommended range for temperature and moisture conditions and will remain so during the curing time for the product.

## 3.03 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a nondestructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without prior acceptance by the Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact.
      a. Installation of anchors in cored holes is not permitted.
      b. Set drill to "rotation only" mode, or to "rotation plus hammer" mode in accordance with the manufacturer's installation instructions and the requirements of the Evaluation Report.
      c. Where edge distances are less than 2 inches and "rotation plus hammer" mode is permitted, use lighter impact equipment to prevent micro-cracking and concrete spalling during the drilling process.
   2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a "condition of use" in the Evaluation Report.
      a. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.

C. Hole diameter: As recommended in the manufacturer's installation instructions and the Evaluation Report.

D. Hole depth: As recommended in the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.

E. Obstructions in drill path:
   1. If an existing reinforcing bar or other obstruction is hit while drilling a hole, unless otherwise accepted by the Engineer, stop drilling. Prepare and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill another hole to the required depth.
      a. Obtain Engineer's acceptance of distance between abandoned and relocated holes before proceeding with the relocation.
      b. Allow dry-pack mortar to cure to a strength equal to that of the surrounding concrete before resuming drilling in the area.
      c. Epoxy grout may be substituted for dry-pack mortar when accepted by the Engineer.
   2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the member and endanger the stability of the structure.
   3. When existing reinforcing steel is encountered during drilling and when specifically accepted by the Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter using pneumatic rotary impact drill.
   4. Bent bar reinforcing bars: Where edge distances are critical and interference with existing reinforcing steel is likely, if acceptable to the Engineer, drill hole at 10-degree (or less) angle from axis of reinforcing bar or all thread rod being installed.

F. Cleaning holes:
   1. Insert air nozzle to bottom of hole and blow out loose dust.
      a. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
      b. Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.
   2. Using a stiff bristle brush with diameter that provides contact around the full perimeter of the hole, vigorously brush hole to dislodge compacted drilling dust.
      a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
      b. Repeat at least 4 times.
   3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and in the number of cycles required by the MPII and the Evaluation Report.
   4. Leave prepared holes clean and dry.
   5. Protect prepared and cleaned holes from contamination and moisture until adhesive is installed.
   6. Re-clean and dry previously prepared holes if, in the opinion of the Engineer, the hole has become contaminated after initial cleaning.

## 3.04 INSTALLATION OF ADHESIVE AND INSERTS

A. Clean and prepare inserts reinforcing bars and all thread rods:
   1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
   2. Solvent clean prepared reinforcing bars and all thread rods over the embedment length in accordance with SSPC SP-1. Provide an oil and grease free surface for bonding of adhesive to steel.

B. Fill holes with adhesive:
   1. Starting at the bottom of the hole, fill hole with adhesive inserting the reinforcing bar or all thread rod.
   2. Fill hole as nozzle is withdrawn without creating air voids.
   3. Unless otherwise indicated on the Drawings, fill hole with sufficient adhesive so that excess adhesive is extruded out of the hole when the reinforcing bar or all thread rod is inserted.
   4. Where necessary, seal hole at surface of concrete to prevent loss of adhesive during curing.

C. Installing reinforcing bars and all thread rods.
   1. Unless otherwise indicated on the Drawings, install bars and rods perpendicular to the concrete surface.
   2. Insert reinforcing bars and all thread rods into adhesive in accordance with manufacturer's recommended procedures.
   3. Confirm that insert has reached the designated embedment in the concrete, and that adhesive completely surrounds the embedded portion.
   4. Securely brace bars and all thread rods in place to prevent displacement while the adhesive cures. Bars and rods displaced during curing will be considered damaged and replacement will be required.
   5. Clean excess adhesive from the mouth of the hole.

D. Curing and loading.
   1. Provide and maintain curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the temperature of the concrete.
   2. Do not disturb or load bonded embeds until manufacturer's recommended cure time, based on temperature of the concrete, has elapsed.

## 3.05 POST-INSTALLATION ACTIVITIES

A. Do not bend bars or all thread rods after bonding to the concrete, unless accepted in advance by the Engineer.

B. Attachments to all thread rods:
   1. After assemblies to be connected are placed, install nuts and washers for threaded rods as indicated on the Drawings.
   2. Draw nuts down tight, using practices specified for "snug tight" installation of bolts in steel to steel connections.

## 3.06 FIELD QUALITY CONTROL

A. Provide field quality control over the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Do not allow work described in this Section to be performed by individuals who do not hold the specified certifications and who have not completed the specified job site training.

C. Manufacturer's services:
   1. Before beginning installation, furnish adhesive manufacturer's technical representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods.
      a. Provide notice of scheduled training to the Engineer and to special inspector(s) not less than 10 working days before training occurs. Engineer and special inspector may attend training sessions.
   2. Submit record, signed by the manufacturer's technical representative, listing Contractor's personnel who completed the training. Only qualified personnel who have completed manufacturer's on-site training shall perform installations.

D. Field inspections and testing:
   1. Hole drilling and preparation.
   2. Results: Submit records of inspections and testing to the Engineer by electronic copies within 24 hours after completion.

## 3.07 FIELD QUALITY ASSURANCE

A. Provide field quality assurance over the Work of this Section as specified in Section 01_45_00 - Quality Control.

END OF SECTION

**SECTION 03_30_01**

**CONCRETE WORK**

**TABLE OF CONTENTS**

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Concrete formwork, concrete accessories, concrete reinforcement, batching and mixing of concrete to be cast-in-place, concrete placement and curing, and tooled concrete finishes.

### 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
   2. MNL-66 - ACI Detailing Manual.
   3. PRC-305 - Specification for Hot Weather Concreting.
   4. PRC-306 - Standard Specification for Cold Weather Concreting.
   5. SPEC-117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
   6. SPEC-301 - Specifications for Concrete Construction.

B. ASTM International (ASTM):
   1. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   2. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   3. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   4. C33 - Standard Specification for Concrete Aggregates.
   5. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   6. C94 - Standard Specification for Ready-Mixed Concrete.
   7. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
   8. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
   9. C150 - Standard Specification for Portland Cement.
   10. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
   11. C171 - Standard Specification for Sheet Materials for Curing Concrete.
   12. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   13. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
   14. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   15. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   16. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
   17. C494 - Standard Specification for Chemical Admixtures for Concrete.
   18. C595 - Standard Specification for Blended Hydraulic Cements.
   19. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

20. C989 - Standard Specification for Slag Cement for Use in Concrete and Mortars.
21. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
22. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
23. C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
24. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
25. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
26. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
27. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
28. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
29. D2103 - Standard Specification for Polyethylene Film and Sheeting.

C. Concrete Reinforcing Steel Institute (CRSI):
   1. Manual of Standard Practice.

## 1.03 TERMINOLOGY

A. The words and terms listed below, are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
   1. Alkali load: Amount of alkalies contributed by the cement in a concrete mixture, expressed in $lb/yd^3$, and calculated by multiplying the cement content of the concrete in $lb/yd^3$ by the alkali content of the Portland cement; or the Portland cement portion of a blended cement, divided by 100.
   2. Average daily temperature: The average of the highest and lowest temperatures during a 24-hour period from midnight to midnight.
   3. Cementitious materials: Portland cement or blended cement and supplementary cementitious materials.
   4. Green concrete: Concrete whose current compressive strength is less than 100 percent of the minimum specified compressive strength, f'c.
   5. Hand mixed concrete: Concrete mixed at or near the point of placement using shovels, hoes, or other similar manually operated tools.
   6. Hot weather: A period when project conditions such as low humidity, high temperature, solar radiation, and high winds promote rapid drying of freshly placed concrete.
   7. Neat cement grout: Grout made from a mixture of Portland cement and water.
   8. Supplementary cementitious material: Inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

## 1.04 SUBMITTALS

A. General:
   1. Submittal as specified in Section 01_33_00 - Submittal Procedures unless modified in this Section.

B. Product data:
   1. Formwork:
      a. Formwork facing materials. Data on facing materials for concrete exposed to view in the finished work, if different from that specified in this Section.
      b. Form release agent. Manufacturer's name and catalog data, including materials safety datasheet and documentation of suitability for use in contact with potable water.
   2. Joint materials:
      a. Preformed expansion joint material: Manufacturer's name and catalog data with documentation of conformance to materials standards specified for each type and thickness of material.
   3. Reinforcement:
      a. Mill certificates for each heat of steel provided.
      b. Reinforcement placement drawings:
         1) Show anchor bolt locations based on anchor bolt templates for approved equipment.
      c. Concrete bar supports:
         1) Precast concrete bar supports ("dobies"): Manufacturer's product data indicating compression strength of concrete supports and material used for tie wires.
         2) Wire chairs and slab bolsters: Manufacturer's product data.
   4. Concrete materials:
      a. Cement:
         1) Mill certificate in accordance with ASTM C150 or ASTM C595. Include "Type" and results of testing for alkali content measured as equivalent alkalies.
      b. Supplementary cementitious materials:
         1) Fly Ash: Identify source and provide testing results documenting compliance with ASTM C618 and any additional requirements of this Section.
         2) Slag cement: Identify source and provide testing results documenting compliance with ASTM C989 and any additional requirements of this Section.
      c. Aggregates:
         1) Type, pit or quarry location, and producer's name.
         2) Commercial laboratory test reports for samples of each aggregate proposed for use. Tests shall have been made not more than 24 months prior to the date of the Submittal.
            a) Fine aggregate: Gradation analysis, specific gravity, reactivity, and reports of deleterious materials to document compliance with ASTM C33.
            b) Coarse aggregate: Gradation analysis, specific gravity, soundness, reactivity, and reports of deleterious materials to document compliance with ASTM C33 for each size used.

d. Admixtures:
    1) Manufacturer's catalog cuts and product data indicating compliance with the standards specified.

5. Concrete mixes: Submit full details, including:
    a. Mix proportions measured by both weight and volume and concrete properties for each class of concrete proposed for use.
        1) Information on correction of batching for varying moisture contents of fine aggregate.
    b. Data to establish the average compressive strength:
        1) If established by field test records, submit:
            a) Product and test data for the materials actually used in the mix.
            b) Actual mix proportions used in the mix producing the record.
            c) Field test data for slump, air content, and 28-day compressive strength. Include not less than 15 tests in accordance with ACI SPEC-301.
        2) If established by testing of trial batches, submit:
            a) Confirmation that the materials and proportions used in the trial batches are those that will be provided for the mix.
            b) Mix test data for slump, air content, and 28-day compressive strength.
        3) For either method, include calculations for:
            a) Standard deviation: Calculated in accordance with ACI SPEC-301 requirements.
            b) Required average compression strength (f'cr) using the standard deviation calculated in accordance with ACI SPEC-301 requirements.
            c) Statement demonstrating that the average compression strength from field test records or from trial batch testing for each mix ($f'c_{avg}$) exceeds the required average compressive strength (f'cr) for that mix.
    c. Data to establish alkali load:
        1) Determine and include the alkali load of the proposed mix.
    d. Data to establish chloride content:
        1) Submit test results showing that the concrete mix contains water-soluble chloride ion content contributed from the constituents including water, aggregates, cementitious materials, and admixtures is less than the limit specified in Table B of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days after mixing.
6. Concrete finishing and curing materials:
    a. Manufacturer's name and product datasheets.

C. Shop Drawings:
    1. Reinforcement:
        a. Submit Drawings showing bending and placement of reinforcement.
            1) Drawings shall be in accordance with ACI MNL-66.
            2) Clearly show placement, shapes, and dimensions of each bar listed in the bill of materials, including additional reinforcement at corners and openings required by details in the Contract Documents.
            3) Show splice locations and bar lengths reflecting Contractor's intended placement sequence.

D. Samples:
   1. Form ties: If requested by the Engineer.
   2. Concrete bar supports: If requested by the Engineer, provide samples of:
      a. Precast concrete bar supports (“dobies”).
      b. Wire chairs and slab bolsters.

E. Procedures:
   1. Contractor’s plans for production, placement, finishing, curing, protection, and temperature monitoring of concrete during the following environmental conditions:
      a. Hot weather.

F. Project record documents:
   1. For the following items, note location of concrete in the structure, and include tag numbers of associated cylinders for compression strength tests.
   2. Concrete delivery tickets. Submit copies of concrete delivery tickets within 24 hours after delivery.
   3. Field test reports: Results of field-testing for slump, temperature, unit weight, and air entrainment.
   4. Testing laboratory reports for compression strength.

G. Notifications:
   1. Modifications to concrete mixes:
      a. Submit notification of any adjustments to mixture proportions and any changes in materials made during the course of the Work for Engineer’s review.
      b. Include details of the changes and supporting documentation.
   2. Joint locations:
      a. Where joint locations other than those indicated on the Drawings are requested, submit proposed locations for Engineer’s review.
      b. Provide Drawings showing proposed joint locations with joint types labeled and joint details referenced.
   3. Reinforcement placement: Where necessary to move reinforcement beyond the specified placing tolerances to avoid interference, submit the proposed arrangement for Engineer’s review.
   4. Concrete placements: Submit notification of readiness for each concrete placement at least 24 hours in advance.
   5. Concrete repairs:
      a. Where concrete surfaces or sections exhibit defects after removal of forms, submit description of existing conditions and of proposed repair procedures and materials.
      b. Include photos of existing conditions with Submittal.

## 1.05 QUALITY ASSURANCE

A. Tolerances on concrete construction: In accordance with ACI SPEC-117 unless more stringent requirements are specified in the Contract Documents.

B. Concrete mixtures:
   1. Ensure that concrete produced has the specified characteristics in the freshly mixed state, and that those are maintained to during transport and delivery and to the point of final placement.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle concrete materials in manner as to prevent damage and inclusion of foreign substances.

B. Deliver reinforcing steel bundled and tagged with identifying tags marked in a legible manner with waterproof markings showing the same designations as indicated on the submitted Shop Drawings.
   1. Store off the ground and protect from moisture, dirt, oil, and other injurious contaminants.

C. Protect concrete accessories from weather and direct exposure to sunlight before installation.

## 1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Hot weather concreting: Construct in accordance with ACI PRC-305 during conditions when the ambient air temperature is above 90 degrees Fahrenheit.
   2. Conditions that promote rapid drying of freshly placed concrete, such as low humidity, high temperature, and wind: Take corrective action to minimize loss of water from the concrete.

## 1.08 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in such a manner that completes any single placing operation to a construction or expansion joint as indicated on the Drawings or accepted by the Engineer in advance of the placement.

# PART 2 PRODUCTS

## 2.01 FORMWORK

A. Forms:
   1. Design and performance requirements:
      a. Design and performance of formwork shall be the responsibility of the Contractor, subject to the requirements of the Contract Documents.
      b. Design, construct, and brace formwork to:
         1) Carry all loads applied or transmitted, including the pressure resulting from placement and vibration of plastic concrete.
         2) Remain tight to prevent loss of mortar.
         3) Maintain specified tolerances and provide finished surfaces as specified.

c. Maximum deflection of facing materials and supporting members on surfaces exposed to view in the finished work: 0.0042 times the clear span (span/240).
d. Maximum deviation from alignment (horizontal or vertical): In accordance with ACI SPEC-117.

2. Form facing materials:
   a. Surfaces exposed to view in the finished work:
      1) Facing materials shall produce a smooth, uniform texture on the concrete.
      2) Do not use materials with raised grain, tears, worn edges, patches, dents, or other similar defects.
      3) Acceptable materials: Plywood with “C” or better face, plastic-faced plywood, tempered concrete form grade hardboard, or steel.
   b. Surfaces not exposed to view in the finished work:
      1) Special form facing material not required.
3. Forms for chamfers and keyways:
   a. Uniform steel, plastic, or lumber section of dimensions shown or specified.
   b. Provide adequate stiffness and support to maintain a true line at the concrete surface.
   c. Treated to eliminate bond with the concrete if required to produce a smooth, uniform, and undamaged finish upon removal.

B. Form ties:
1. General:
   a. Provide form ties fabricated by recognized manufacturer of concrete forming equipment and suitable for use with the forming system selected.
   b. Provide ties that accurately tie, lock, and spread forms:
      1) Do not use wire ties or wood spreaders.
   c. Provide form ties manufactured such that, when forms are removed, the tie leaves no metal or other material within 1-1/2 inches of the surface of the concrete.
   d. Do not allow tie holes through forms for ties to leak during concrete placement.
2. Cone snap ties: Tie with removable plastic cone leaving a tapered depression having a minimum diameter of 1 inch at the surface of the concrete and a depth of 1-1/2 inches below the surface.

C. Dry-pack mortar for filling cone snap tie holes:
1. Proportioned mix of 1 part of Portland cement to 1 part plaster sand with potable water added to provide a stiff consistency that can be driven into holes and properly compacted.
2. For repairs in concrete exposed to view in the finished work, mix repair mortar using the same cement and sand as that used for the concrete being patched.
   a. Mix a trial batch and confirm color compatibility with the surrounding material.
   b. Adjust color to match that of the surrounding concrete by adding white Portland cement if necessary.
3. Admixtures or additives to mortar are not permitted.

D. Form release agent: Commercially manufactured, non-staining formwork release agent that will prevent absorption of water by the formwork and will prevent bond between the formwork and the concrete.
    1. Form release agent to comply with local air quality management regulations.

## 2.02 JOINT MATERIALS

A. Synthetic sponge rubber expansion joint material:
    1. Elastic sponge rubber compound in accordance with ASTM D1752, Type I.
    2. Concrete-gray color unless otherwise noted.
    3. Thickness: As indicated on the Drawings.
    4. Manufacturers: One of the following or equal:
        a. Williams Products Inc., Everlastic 1300.
        b. WR Meadows, Seal Tight Sponge Rubber Expansion Joint.

B. Bituminous fiber expansion joint material:
    1. Thickness: To match joint width indicated on the Drawings.
    2. Asphalt-impregnated fiberboard in accordance with ASTM D1751.
        a. Manufacturers: One of the following or equal:
            1) Durajoint.
            2) W.R. Meadows, SealTight Fibre Expansion Joint.

C. Sealants and caulking: As specified in Section 07_92_00 - Joint Sealants.

## 2.03 REINFORCEMENT

A. Materials:
    1. Deformed bars: In accordance with ASTM A615 Grade 60**.**
    2. Welded wire fabric: Sheets of plain wire in accordance with ASTM A1064.
    3. Bar supports:
        a. Over ground or “mud mat”:
            1) Precast concrete blocks with cast-in annealed steel tie wires, 16 gauge or heavier.
                a) Compressive strength of blocks equal to or exceeding the compressive strength of the surrounding concrete.
            2) Height as required for minimum 3 inches of clear concrete cover below reinforcement.
            3) Minimum block “footprint” of 4 square inches, or as required to supporting load from reinforcement while maintaining the required concrete cover.
        b. Wire supports: Class 3, bright basic wire with galvanized coating in accordance with CRSI Manual of Standard Practice.
    4. Tie wire: Annealed steel.

B. Fabrication:
    1. Cut and cold-bend bars in accordance with provisions of ACI MNL-66 and ACI CODE-318.
    2. Fabricate reinforcement to the tolerances in accordance with ACI SPEC-117.
    3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

## 2.04 SOURCE QUALITY CONTROL

A. Submit documentation that the proposed concrete mixes will conform to the requirements of this Section and will produce concrete having the required proportions and properties specified.
   1. Do not place concrete until the design for that mix and the results of any trial batch testing have been accepted by the Engineer.
   2. If the Engineer requires changes to the mix design, modify mixes within limits set forth in this Section and submit new mix design for Engineer's review.

B. After acceptance, do not change mixes or mix proportions without prior acceptance by the Engineer.
   1. Exception: At all times, adjust batching of water to compensate for free moisture content of aggregates. Total water content in the mix shall not exceed that specified.

C. If there is change in source of cement or aggregate, or if there is a significant change in the characteristics or quality of any constituent material received from a source accepted to supply materials, submit new design mixes for each class of concrete affected.

D. Testing of materials and mixes before placement to demonstrate that they comply with the requirements of this Section shall be at the Contractor's expense.

## 2.05 CONCRETE MIXES

A. Constituent materials:
   1. Cement:
      a. Portland cement: In accordance with ASTM C150, Type I or II:
         1) Cement for finishes or repairs: Provide cement from same source and of same type as concrete to be finished.
   2. Blended hydraulic cement:
      a. In accordance with ASTM C595:
         1) Type IL (MS).
   3. Supplementary Cementitious Materials (SCM):
      a. Fly ash:
         1) In accordance with ASTM C618, Class F.
         2) Sampling and testing: In accordance with ASTM C311.
         3) Loss on ignition: Not to exceed 4 percent.
      b. Slag cement:
         1) Grade 80, 100, or 120 in accordance with ASTM C989, except as modified below:
            a) Fineness: Amount retained on a No. 325 sieve: 20 percent maximum.
            b) Total alkalies $Na_2O + 0.658\ K_2O$:
               (1) Minimum: 0.60 percent.
               (2) Maximum: 0.90 percent.

4. Aggregates:
    a. General:
        1) Provide normal weight concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of the amounts specified.
        2) Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, or other construction waste.
        3) Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operations.
        4) Alkali-silica reactivity:
            a) Provide fine and coarse aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 and with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260 and not greater than 0.04 percent at 1 year when tested in accordance with ASTM C1293.
    b. Fine aggregate:
        1) Provide fine aggregate consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.
        2) In accordance with ASTM C33.
    c. Coarse aggregate:
        1) Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances; and in accordance with ASTM C33, Class 4S.
        2) Grading: Unless otherwise specified or accepted in writing by the Engineer, provide the following:
            a) Aggregate for Class A, C, and PM Concrete: ASTM C33, Size Number 57.
            b) Aggregate for Class CE Concrete: ASTM C33, Size Number 8.
            c) Where a combination of 2 or more sizes of coarse aggregate are used, the gradation of the blend shall conform to the grading requirements in accordance with ASTM C33 for the size number specified.
5. Water:
    a. Water for concrete mixes, for washing aggregate, and for curing concrete: Potable water, clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
    b. Do not exceed the optional chemical limits of ASTM C1602.
6. Admixtures:
    a. General:
        1) Do not use admixtures, except those specified, unless written authorization has been obtained from the Engineer.
        2) Admixtures shall be compatible with concrete and other admixtures. Admixtures (other than fly ash) shall be the products of a single manufacturer to ensure compatibility.
        3) Do not use admixtures containing chlorides in excess of 0.5 percent by weight of cement when calculated as chloride ion.
    b. Air entraining admixture: In accordance with ASTM C260.

c. Water reducing admixture:
    1) In accordance with ASTM C494, Type A or Type D.
    2) Not containing air-entraining agents.
d. High range water reducing admixtures/plasticizing admixtures:
    1) High-range water reducing admixtures: In accordance with ASTM C494, Type F.
    2) Use shall produce non-segregating concrete mixture with little bleeding that remains in a plastic state for not less than 2 hours.

B. Mix design and proportioning:
    1. Proportion mixes to provide compression strength, workability, and durability as specified in this Section.
    2. Submit documentation that the proposed mixes will conform to the requirements of this Section and will produce concrete having the required properties.
    3. Compression strength:
        a. Proportion each concrete mix to provide the required average compressive strength (f'cr) determined in accordance with the provisions of ACI SPEC-301.
        b. Determine required average compressive strength (f'cr) for each class of concrete using the specified compressive strength of the mix, f'c, and the standard deviation determined in accordance with ACI SPEC-301.
            1) Establish the standard deviation in accordance with ACI SPEC-301 and based on either field test records or based on trial batches.
            2) Documentation of standard deviation based on field test records:
                a) Calculate standard deviation in accordance with ACI SPEC-301 procedures using test records that:
                    (1) Represent materials, quality control procedures, and conditions similar to those expected for this Work.
                    (2) Do not include provisions for materials and proportions that are more restrictive than the materials proposed for use in this Work.
                    (3) Represent a mix proportioned to provide a specified compressive strength (f'c) within 1,000 pounds per square inch of that specified for the corresponding mix in this Section.
            3) Documentation of standard deviation based on trial batches plus empirical code requirements:
                a) When records including at least 15 consecutive tests that span a period of at least 45 calendar days are not available, determine required average compressive strength (f'cr) from Table A:

**Table A: Required Average Compressive Strength**

| Specified Compressive Strength f'c (pounds per square inch) | Required Average Compressive Strength f'cr (pounds per square inch) |
|---|---|
| Less than 3,000 | f'c + 1,000 |
| 3,000 to 5,000 | f'c + 1,200 |

4. Workability:
    a. Provide concrete with workability and consistency that can be readily worked into corners and angles of forms and around reinforcement without excessive vibration and without permitting materials to segregate or free water to collect on the surface.
5. Cement content:
    a. Cementitious materials content: Conform to values specified in Table B of this Section.
    b. Ratio of water to cementitious materials:
        1) Conform to values specified in Table B of this Section.
        2) Total water, including that from moisture content of aggregates and admixtures, shall not exceed that specified in Table B of this Section.
6. Supplementary Cementitious Materials:
    a. Fly ash:
        1) Maximum of 20 percent by weight of total weight of cementitious materials (cement plus fly ash).
        2) Other supplemental cementitious materials shall not be used without prior acceptance by the Engineer.
    a. Slag cement:
        1) Minimum slag cement content: 20 percent of the total weight of cementitious materials.
        2) Maximum slag cement content: 30 percent of the total weight of cementitious materials.
7. Aggregates:
    a. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete classes, with exception of Class CE.
8. Admixtures:
    a. Use in accordance with manufacturer’s instructions.
    b. Air entraining admixture:
        1) Provide concrete with entrained air content indicated in Table B of this Section and consisting of evenly dispersed air bubbles.
    c. Water reducing admixture:
        1) Required in all concrete mixes.
    d. High range water reducing admixture/plasticizing admixture:
        1) Proportion for a slump of 2 to 4 inches before the admixture is added, and a maximum slump of 8 inches after the admixture is added.
9. Concrete mix design requirements by class:
    a. Provide concrete mixes for each “class” specified in this Section and indicated in Table B of this Section.
    b. Use each class at the locations specified in the following paragraphs or indicated on the Drawings.
        1) “Class A” concrete: General use. Use at all locations unless otherwise indicated on the Drawings or listed in the following paragraphs.
        2) “Class C” concrete: May be used as fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and elsewhere as indicated on the Drawings.
        3) “Class CE” concrete: Use for electrical conduit and duct bank encasements.
        4) Class PM concrete: Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.

c. Pumped concrete: Provide a separate mix design and substantiation testing for each “class” to be placed by pumping.

**Table B: Concrete Classes**

| Concrete Class | Minimum Specified Compressive Strength at 28 days, f'c[1] (pounds per square inch) | Ratio of water to cementitious materials[2,3] (minimum - maximum) | Cementitious Materials Content[3] (pounds per cubic yard of concrete by weight) | Cement Type | Maximum Chloride Content (percent by weight of cement) | Maximum Coarse Aggregate Size[4] | Air Entrainment (percent) (N/R: not required) | Admixtures required[5] | Slump Range (inches) |
|---|---|---|---|---|---|---|---|---|---|
| A | 4,500 | 0.40 to 0.45 | 535 to 575 | ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS) | 0.15 | 57 | 6±1.5 | AEA WRA | 2 to 4 |
| C | 2,500 | 0.62 max. | 423 min. | ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS) | No limit | 57 | 6±1.5 | AEA WRA | 3 to 6 |
| CE | 2,500 | 0.62 max. | 423 min. | ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS) | No limit | 8 | 5±1.5 | AEA WRA | 3 to 6 |
| PM | 5,000 | 0.40 | 535 to 575 | ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS) | 0.15 | 57 | 5+1.5 | AEA WRA | 3 to 6 |

Notes:

(1) At locations where concrete will not be subjected to load from other elements of the structure or from Contractor’s placing operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Contractor’s Engineer.
(2) W/C Ratio = Ratio of water to cementitious materials (Portland cement plus supplemental cementitious material) by weight Include weight of admixtures in the water content of the mix when the quantity of the admixtures exceeds 10 ounces per 100 pounds of cement.
(3) Provide mix within the range of W/C ratio and cementitious materials content indicated.
(4) Size number in ASTM C33, Table 2.
(5) Admixtures are designated as follows:

AEA: Air entraining admixture.

HRWR: High-range water reducing admixture.

| Table B: Concrete Classes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Concrete Class | Minimum Specified Compressive Strength at 28 days, f'c[1] (pounds per square inch) | Ratio of water to cementitious materials[2,3] (minimum - maximum) | Cementitious Materials Content[3] (pounds per cubic yard of concrete by weight) | Cement Type | Maximum Chloride Content (percent by weight of cement) | Maximum Coarse Aggregate Size[4] | Air Entrainment (percent) (N/R: not required) | Admixtures required[5] | Slump Range (inches) |
| WRA: Water reducing admixture. | | | | | | | | | |

## 2.06 CONCRETE BATCHING AND MIXING EQUIPMENT

A. Provide equipment and facilities for accurate measurement and control of materials.
   1. At all times, maintain proportions of concrete mix within specified limits.
   2. Control and adjust batch weights to secure maximum yield.

B. Measuring or weighing equipment:
   1. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   2. Devices shall bear the current and valid seal of the Sealer of Weights and Measures in the Authority having jurisdiction.
   3. Furnish devices capable of providing successive quantities of individual materials measured to within 2 percent of desired amount of that material.

C. Mixing equipment:
   1. Mixes shall be ready-mix or transit-mixed concrete in accordance with ASTM C94.
   2. Provide equipment capable of combining aggregates, cementitious materials, water, and admixtures into a thoroughly mixed and uniform mass during the time periods specified, and capable of discharging the resulting mixture without segregation.
   3. Maintain mixing equipment in good working order. Operate at loads and speeds, and for periods of time recommended by the manufacturer or specified in this Section.

## 2.07 CONCRETE FINISHING AND CURING MATERIALS

A. Evaporation retardant:
   1. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Eucobar.
      b. Master Builders Solutions/Sika, MasterKure ER 50.

B. Plastic membrane for curing:
   1. White polyethylene film in accordance with ASTM C171:
      a. Nominal thickness not less than 0.0040 inches when measured in accordance with ASTM D2103, and thickness at any point not less than 0.0030 inches.
      b. Loss of moisture: Not to exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

C. Sprayed membrane curing compound:
   1. In accordance with ASTM C309, Type 1D. Clear with fugitive dye.

## PART 3 EXECUTION

### 3.01 GENERAL

A. Preparation:
   1. Use construction methods and sequences that allow time for concrete to reach adequate strength to prevent damage to or overstress of the concrete structure or its elements during construction.
   2. Locations of construction and expansion joints are indicated on the Drawings.
      a. Make no other joints, except as accepted in advance by the Engineer.
      b. Schedule placing of concrete to complete any single placing operation between designated joints.
      c. Schedule and sequence placements to allow adequate time for concrete to achieve adequate strength before subsequent placements and loads are applied to the structure.

B. Verification of conditions:
   1. Do not place concrete until:
      a. Forms have been thoroughly cleaned of dirt and debris, and form release agents have been applied.
      b. Forms have been thoroughly checked for alignment, level, strength, and accurate location of reinforcement, joint accessories, and mechanical and electrical inserts or other embedded items.
      c. Reinforcement is secure and properly fastened in its correct position.
      d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
      e. Forms are aligned and secured, and loose form ties at construction joints have been retightened.
   2. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the work:
      a. Provide this notification in advance of operations, allowing such time as the Engineer deems necessary to make final observation of preparations at location of the concrete placement.
      b. Have forms, reinforcement, screeds, anchors, ties, embeds, and inserts in place before notifying Engineer of readiness for final observations.
   3. Do not place concrete until Engineer has completed final observations of conditions at the placement and has given acceptance to proceed.

## 3.02 FORMING

A. General:
   1. Do not use earth cuts as forms for vertical or sloped surfaces unless specifically required by or indicated on the Contract Documents.
   2. Joints: Locate joints as indicated on the Drawings:
      a. Submit joint locations other than or differing from those indicated on the Drawings for Engineer's review before construction.
   3. Chamfers:
      a. Permanently exposed outside corners: Provide 3/4-inch chamfer.
      b. Re-entrant corners:
         1) Chamfer not required.
         2) Corner may be left square.
      c. Edges of formed joints: Chamfer not required except where indicated on the Drawings.
   4. Level strips: Install level strips at top of wall concrete placements to maintain true line at horizontal construction joints.

B. Constructing and erecting formwork:
   1. Brace and anchor formwork to ensure vertical and lateral stability and to maintain finish tolerances when subjected to uplift pressures and lateral pressures from plastic concrete.
      a. Ensure that formwork is positioned, braced, and firmly held against previously placed concrete to maintain flush surfaces and to prevent loss or leaking of mortar at construction joints.
         1) At joints with flush surfaces exposed to view, lap contact surface of form a maximum of 1 inch over the previously placed concrete.
      b. Design and construct forms with sufficient strength and stiffness that deflections resulting from loading by plastic concrete will not exceed the surface tolerance limits specified.
      c. Set forming materials in an orderly and symmetrical arrangement, keeping the number of seams to a practical minimum.
      d. Form ties: Tie forms together using cone snap ties placed at not more than 2-foot centers vertically and horizontally.
      e. Construct formwork to permit easy removal without damage to formed surfaces.
      f. Provide temporary openings at the base of column and wall formwork to allow cleaning and inspection immediately before concrete placement.
      g. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16-inch or larger by tightening forms or by filling with acceptable crack filler.
   2. Where forms are reused, clean surfaces of mortar, grout, and foreign materials before coating with form release agent and setting.
   3. Cover formwork surfaces with form release agent to prevent bond with the concrete:
      a. Do not allow form release agent to puddle in the forms.
      b. Do not allow form release agent to contact reinforcement, embeds, or previously placed concrete.
   4. Provide runways supported directly on the formwork for moving equipment and supplies during preparations for concreting:
      a. Do not rest such runways on reinforcement.

C. Embeds, joints, and accessories:
   1. Position pipes, sleeves, conduits, inserts, anchors, castings, and other embedded items in the forms, and anchor to formwork to prevent displacement.
   2. Fill voids in sleeves, pipes, inserts and anchor slots with readily removable material, and seal if required to prevent entry of mortar.
   3. For pipe or conduit runs, position embeds to allow at least 3 inches of clear concrete separation between parallel runs of pipes, conduits or any combination of these items with each other or with reinforcement.

D. Removing formwork:
   1. Remove forms after the specified time for curing and protection has been provided and when operations will not damage concrete.
   2. Immediately after forms are removed, carefully examine concrete surfaces.
      a. Report any irregularities in surfaces and finishes to the Engineer.
      b. Where surface repairs are needed, contact Engineer with description of conditions and description of repair procedures before proceeding with work.
   3. Immediately follow form removal with installation of specified curing materials and procedures.
   4. After forms are removed from wall and curing is complete, fill tie holes as follows:
      a. Remove form ties and cones from surfaces.
      b. Roughen cone-shaped tie holes by heavy sandblasting before repair.
      c. Clean and dampen tie holes, maintaining a saturated surface for at least 2 hours before applying dry-pack mortar.
      d. Dry pack cone-shaped tie holes with dry-pack mortar as specified in this Section.

## 3.03 PLACING CONCRETE REINFORCEMENT, EMBEDS, AND ACCESSORIES

A. Preparation:
   1. Cut and bend deformed steel reinforcement in the shop and deliver completed bars to the site for installation.
      a. Do not field-bend deformed reinforcement.
   2. Surface preparation:
      a. Thoroughly clean reinforcing bars from rust scale, loose mill scale, rust coat, dirt, oil, and other coatings that adversely affect bonding capacity when placed in the work.
         1) Thin coating of red rust resulting from short exposures will not be considered objectionable.
      b. Remove concrete or other deleterious coatings on dowels and other reinforcement projecting from previous placements by wire brushing or sandblasting before the reinforcement is embedded in the subsequent placement.

B. Support of reinforcement and accessories:
   1. Provide supports for deformed bars and wire fabric to maintain reinforcement position indicated on the Drawings and to provide specified minimum clear concrete cover around the reinforcement.

2. Use number of supports required to prevent reinforcement from sagging and to support loads during construction, but in no fewer quantities and locations than recommended by ACI MNL-66 and CRSI Manual of Standard Practice.
3. Support wire fabric from reinforcing supports:
    a. Do not place wire fabric on grade or forms for subsequent lifting into plastic concrete during the concrete placement.
    b. Take care to maintain specified position of wire fabric in the concrete section and to prevent bending, draping, or kinking of the wires.
4. Do not:
    a. Use brick, broken concrete masonry units, concrete spalls, rocks, or other such material for supporting reinforcement.
    b. Support reinforcement on additional reinforcing bars installed with less cover than that required by the Contract Documents ("give away bars").
    c. Adjust location of reinforcement indicated on the Drawings to increase cover over support bars.
5. Furnish and use templates for placing column and wall dowels.

C. Placing reinforcement:
1. Locate reinforcement to provide minimum clear concrete cover specified:
    a. Where cover is not specified, provide cover in accordance with ACI CODE-318.
2. Accurately place reinforcement in accordance with the tolerances of ACI SPEC-117:
    a. Where reinforcement must be moved beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embeds, submit the proposed arrangement for Engineer's review.
3. Fasten reinforcement securely in place with wire ties:
    a. After tying, bend ends of wire ties inward towards the center of the concrete to match clear concrete cover provided for reinforcement.
4. Do not weld reinforcing bars or wires.
5. Deformed reinforcing bars:
    a. Tie slab bars at every intersection around the perimeter of slabs.
    b. Tie wall bar and slab bar intersections, other than those around the perimeter, at every 4$^{th}$ intersection, but not more than 48 inches on center each way.
    c. Lap splices:
        1) Lap reinforcement at splices as indicated on the Drawings or specified.
        2) Unless indicated on the Drawings, install lap splices with bars in contact and fastened together with tie wire.
        3) If lap splice length is not indicated on the Drawings, provide lap splice equal to 40 times reinforcing bar diameter.
6. Welded wire fabric reinforcement:
    a. Bend fabric as indicated on the Drawings or required to fit work.
    b. Straighten fabric to make reinforcement in each face a flat, planar surface before placing in the Work.
    c. Extend welded wire fabric across concrete section to provide fabric to within 2 inches of vertical concrete edges.

d. Lap splice welded wire fabric as indicated on the Drawings:
    1) If no splice details are indicated, lap fabric at least 12 inches, fasten with wire ties spaced not more than 24 inches on center, and lace lap with wire of the same diameter of the fabric.

## 3.04 BATCHING, MIXING, TRANSPORTING, AND DELIVERING CONCRETE

A. General:
    1. Measure, batch, mix, transport, and deliver ready-mixed concrete in accordance with ASTM C94.

B. Measuring and batching:
    1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
        a. Weigh cementitious materials separately.
    2. Furnish satisfactory means for checking moisture content of aggregates before batching.
        a. Adjust mix water to compensate for free moisture content of aggregate.
    3. Mixing water:
        a. Measure by volume or by weight.
        b. Maximum water-to-cementitious materials ratio for each concrete class shall not exceed that specified in Table B of this Section.
    4. Admixtures:
        a. Provide admixtures as specified.
        b. Batch products by means of mechanical batcher capable of accurate measurement, and in accordance with the admixture manufacturer's instructions.

C. Mixing and transporting:
    1. Mixing:
        a. Equip each truck mixer with device capable of counting number of drum revolutions and interlocked to prevent discharge of concrete from drum before required number of revolutions is complete.
        b. Once drum revolutions commence, continuously revolve drum until it has completely discharged its batch.
        c. Do not add water until drum commences revolutions.
        d. Engineer may require an increase in the designated minimum number of revolutions, or a decrease in the designated maximum number of revolutions if necessary to obtain satisfactory mixing.
            1) Incorporate such changes without additional costs to County.
    2. Do not exceed the following time period for mixing and delivery:
        a. Total elapsed time from addition of water at batch plant through discharging of mix: Not to exceed the lesser of 90 minutes or 300 revolutions of the mixer drum.
        b. Total elapsed time for from arrival at the project site to completing discharge of mix: Not to exceed 30 minutes.
        c. Under conditions contributing to quick setting, the Engineer may reduce total elapsed time permitted.

D. On-site acceptance of concrete mixes:
   1. Concrete shall possess the properties specified in this Section at the point of placement.
   2. Do not place concrete:
      a. Having slump outside the limits indicated in Table B of this Section.
      b. That does not conform to specifications for entrained air content.
      c. For which the total elapsed time of mixing or elapsed time at the site exceeds the specified maximums.

## 3.05 CONVEYING, DEPOSITING, AND CONSOLIDATING CONCRETE

A. Preparation:
   1. General:
      a. Clean construction joints and forming surfaces of dirt, sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement.
         1) Use vacuum cleaner if required to provide clean surfaces.
      b. Remove snow, ice, frost, and standing water from surfaces of formwork, reinforcement, and embeds in contact with concrete.
      c. Secure reinforcement, joint materials, anchors, embeds, and other items in place.
      d. During conveying, placement, consolidation, and finishing of concrete, protect surrounding construction, including concrete walls and slab surfaces, from concrete splatter.
      e. Thoroughly clean surrounding construction at the completion of each placement and before splatter sets up.
   2. Concrete construction on grade:
      a. Provide subgrade preparation, base materials, and compaction as required by the Contract Documents.
      b. Remove loose soils, debris, standing water, snow, or ice from subgrade.
      c. Provide moist subgrade with no standing or free water and no muddy or soft spots.
         1) When subgrade is not moist, sprinkle with water not less than 2 or more than 6 hours in advance of placing concrete.
         2) If subgrade becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
   3. Weather conditions:
      a. Hot weather: In hot weather conditions, make provisions in advance of placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering.
      b. Precipitation:
         1) Do not begin placements while rain, sleet, or snow is falling or anticipated, or unless adequate protection is provided.
         2) Do not allow precipitation to increase concrete water content or to damage the surface of the concrete.
      c. Wind:
         1) Do not begin placements during wind events that will blow dust or debris into the plastic concrete.
         2) Do not allow wind-blown debris to become embedded in or to damage the surface of the concrete.

3) At all times, have sufficient coverings on hand to protect new concrete from excessive drying or blowing debris.

B. Conveying concrete:
   1. Convey concrete from mixer to place of final deposit by methods that prevent segregation or loss of materials.
   2. Use chutes, pumps, and conveyors of size and design that will ensure continuous flow of concrete at point of delivery without cold joints.
   3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from the chute or conveying device.
   4. Keep conveying equipment clean by thoroughly washing and scraping upon completion of any placement.

C. Depositing concrete:
   1. Do not place concrete under the following conditions:
      a. After initial set has occurred.
      b. When re-tempering has occurred.
   2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
      a. Do not use vibrators to move concrete from its point of deposit.
      b. Use tremies for placing concrete where drop is over 5 feet.
   3. Place concrete continuously in approximately horizontal layers not exceeding 24 inches in depth. Bring level up evenly in all parts of forms.
      a. After placement begins, continue without significant interruption and as a continuous operation until the end of that placement is reached.
      b. Do not allow “cold joints” to form between adjacent layers or areas of the placement, or initial set to form on “wet edge” of placements.
      c. Take precautions to prevent delays between placement of adjacent layers or areas from exceeding 20 minutes.
         1) If more than 20 minutes elapse after the initial surface was placed, spread a layer of neat cement grout, as specified for construction joints before depositing additional concrete.
   4. Placing concrete on slopes: Commence placement at bottom of slope and work upward.
   5. Placing horizontal concrete monolithically with structures below:
      a. If concrete for slabs, beams, or walkways is to be cast monolithically with walls or columns below, do not place the horizontal concrete elements until the concrete in walls or columns below has been placed, consolidated, and allowed to achieve initial set.
      b. Allow set time of not less than 1 hour.
      c. Maintain a moist surface at the top of the walls or columns during the setting period.
   6. Placing a second concrete lift over hardened concrete below:
      a. Take special precautions in form work at top of old lift and bottom of new lift to prevent:
         1) Spreading and vertical or horizontal displacement of forms.
         2) Grout “bleeding” onto finished concrete surfaces.

D. Consolidating concrete:
   1. Thoroughly consolidate concrete into forms and around reinforcement, pipes, and other embeds using mechanical vibrators.
      a. Take special care to place concrete solidly against forms, leaving no voids.
      b. Make concrete solid, dense, compact, and smooth.
   2. Provide vibration energy sufficient to cause concrete to flow and readily settle into place, leaving no voids. Vibration should visibly affect concrete over a radius of at least 18 inches without segregation.
   3. Vibrators:
      a. At all times, have sufficient vibrators on hand to consolidate concrete as it is placed.
      b. In addition to vibrators in use while concrete is being placed, have on hand at least 1 spare vibrator in serviceable condition.
      c. Place no concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.

## 3.06 FINISHING CONCRETE

A. Provide concrete finishes as specified in Section 03_35_29 - Concrete Finishes.

B. Liquid evaporation retardant:
   1. Apply evaporation retardant when environmental conditions will result in rapid evaporation of moisture from the surface of the fresh concrete during finishing operations. Such conditions include low humidity, high heat, and wind occurring alone or in combination.
   2. Immediately after the concrete is screeded, coat the surface of the concrete with a liquid evaporation retardant.
   3. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks and crazing at the surface.

## 3.07 CURING AND PROTECTING CONCRETE

A. Curing concrete:
   1. Cure concrete by methods specified in this Section.
   2. Keep concrete continuously moist and at a temperature of at least 50 degrees Fahrenheit for at least 7 days after placement unless the details of a particular method specify a longer period.
   3. Make provisions to maintain moisture or curing membrane integrity at edges of slabs, tops of walls, and joint surfaces, and to prevent loss of protection.
   4. Schedule of curing methods:
      a. Concrete surfaces that will receive additional materials that require bond to the initial placement (including concrete; concrete repairs, coatings, paints, sealers; grout; and other materials):
         1) Water curing or plastic membrane curing.
      b. Formed surfaces:
         1) If non-absorbent forms are left in place for 7 days after placement: No additional requirements.
         2) For absorbent forms or when forms are removed during the 7 days following placement: Cure by water curing, plastic membrane curing, or sprayed membrane curing.

c. Unformed concrete surfaces:
    1) Water curing, plastic membrane curing, or sprayed membrane curing.

5. Water curing:
    a. Keep surfaces of concrete constantly and visibly saturated by ponding, continuous fogging, or continuous sprinkling at all times during curing period.
        1) Cover surfaces if required to maintain saturated conditions.
        2) For horizontal surfaces, pond the surface with at least 2 inches of water or cover with saturated mats or fabric kept continuously wet.
    b. Formed surfaces:
        1) Each day forms remain in place may be counted as 1 day of water curing.
        2) Do not loosen form ties while concrete is being cured by forms left in place.
        3) No further credit for curing time will be allowed after contact between the concrete surface and the forms has been broken.
6. Plastic membrane curing:
    a. Cover concrete with plastic membrane, sealing joints and edges against displacement by wind or site operations and to prevent loss of moisture.
    b. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
    c. Keep all surfaces of concrete under plastic membrane moist at all times during the curing period.
7. Sprayed membrane curing:
    a. Application of curing compound:
        1) Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
            a) If more than 1 hour elapses between removal of forms and application of curing compound, provide water curing of affected surfaces for the full curing period.
        2) Contractor is cautioned that the method of applying curing compound specified in this Section may require more compound than normally suggested by manufacturer of compound, and also more than is customary in the trade.
        3) Apply curing compound by mechanical, power-operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
        4) Apply compound in at least 2 coats, with each subsequent coat in a direction turned 90 degrees from the preceding coat.
        5) Apply curing compound in sufficient quantity that concrete has uniform appearance and that the natural color of the concrete is effectively and completely concealed immediately after spraying.
        6) Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
        7) Apply compound to a film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
        8) Take care to apply curing compound to edges of placements and over full surface profile of construction joints.
    b. Removal of curing compound:
        1) Do not remove curing compound from concrete in less than 7 days after application.

2) Before placing fresh concrete against a surface previously coated with curing compound, remove the curing compound by heavy sandblasting, or alternate method acceptable to the Engineer.
3) Prior to final acceptance of the work, remove any curing compound on surfaces exposed to view by sandblasting or other acceptable method. After removal, only the natural color of finished concrete shall remain visible, and such color shall be uniform over the entire surface.

B. Protecting concrete:
1. Immediately after placement, protect concrete from hot or cold weather, and mechanical damage.
2. Temperature:
a. Cold weather: Protect concrete during the curing period so that the concrete temperature is maintained within the following requirements.
1) Sections less than 12-inches thick: Minimum 55 degrees Fahrenheit.
2) Sections 12- to 36-inches thick: Minimum 50 degrees Fahrenheit.
b. Hot weather: Protect concrete during the curing period so that the concrete temperature does not exceed 90 degrees Fahrenheit.
c. Remove protection against temperature gradually so that concrete surface temperature does not drop or rise by more than 40 degrees Fahrenheit during any 24-hour period.
3. Maintain forms, shoring, and bracing in place after concrete placement for a period after concrete placement as indicated in the following paragraphs. Forms may be removed after these periods if the concrete has developed sufficient strength and hardness to resist surface or other damage.
a. Vertical forms:
1) General: Minimum 24 hours after concrete placement.
2) Sides of footings: Minimum 24 hours after concrete placement.
3) Sides of beams, girders, and similar members: Minimum 48 hours after concrete placement.
b. Horizontal forms:
1) Slabs, beams, and girders: Until concrete reaches specified compressive strength, f'c, or until shoring is installed.
c. Shoring for slabs, beams, and girders:
1) Shore until concrete strength reaches specified compressive strength, f'c.
a) Temporary shoring may be required after the specified compressive strength is reached if construction loads will exceed the designated live load capacity of the structure.
d. Wall bracing:
1) Brace until strength of concrete beams and slabs laterally supporting the wall reaches specified compressive strength, f'c.

C. Loads against or on the concrete:
1. Loading of green concrete, by backfilling or by placing personnel and equipment on the surface, is not permitted.
2. Backfilling: Do not place backfill against concrete walls until the wall and all elements attached to it, including connecting slabs or beams, are fully braced by the structure, and have achieved their minimum specified compressive strength, f'c.

## 3.08 JOINTS AND JOINT PREPARATION

A. Joint locations and details:
   1. Construct concrete work as monolith to the extent practical.
   2. Construct joints as indicated on the Drawings and as specified.
   3. Locations of construction, expansion, and other joints are indicated on the Drawings or specified in this Section.
      a. Do not relocate, add, or delete joints without prior approval from the Engineer.

B. Construction joints:
   1. Where spacing is not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
   2. Construct as indicated on the Drawings.
   3. Before placing fresh concrete against the joint: Use heavy sandblast to thoroughly clean joint surfaces and reinforcement crossing the joint of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter.
   4. Just before placing concrete against the joint, wash surface with water to saturate joint surface and concrete surfaces within 12 inches of the joint.
   5. Horizontal joints:
      a. Immediately before placing concrete, thoroughly spread bed of neat cement grout over the joint surface. Grout shall be as follows:
         1) Use same sand-to-cementitious materials ratio that is used for concrete mix.
         2) Use same materials that are used for concrete.
         3) Use water-to-cementitious materials ratio that is no more than that specified for concrete.
      b. Grout thickness: Not less than 1/2 inch, or more than 1 inch.

C. Expansion joints:
   1. Where width is not indicated on the Drawings, provide 3/4-inch wide joint.
   2. Construct as indicated on the Drawings.
   3. Do not extend reinforcement, conduits, or other items through expansion joints unless details for such crossings are indicated on the Drawings.
   4. Preformed expansion joint material:
      a. Accurately position joint filler in the joint.
         1) Fasten to concrete or forms with adhesive.
         2) Fastening joint filler using nails, bolts, screws, or similar items is not permitted.
      b. Tape splices in joint filler to prevent intrusion of mortar.

## 3.09 TOLERANCES

A. Concrete:
   1. Finished concrete: Conform to shapes, lines, grades, and dimensions indicated on the Drawings.
   2. In accordance with ACI SPEC-117, except as modified in the following paragraphs:
      a. Where more restrictive tolerances to accommodate equipment are indicated on the Drawings.

b. Slabs where slope is indicated:
    1) Uniformly slope to drain.
    2) Without depressions that puddle water.
c. Slabs indicated to be level:
    1) Maximum deviation of 1/8 inches in 10 feet without any apparent changes in grade.
    2) Without depressions that puddle water.

B. Embeds:
1. General:
    a. Sleeves and inserts: Plus or minus 1/8 inch.
    b. Projected ends of anchor bolts: Plus 1/4 inch; minus 0 inches.
    c. Anchor bolt position: Plus or minus 1/16 inch.
2. Equipment: Set inserts to tolerances required for proper installation and operation of equipment or systems to which insert pertains.

## 3.10 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Field tests:
1. During progress of construction, provide testing to determine whether the concrete, as being produced, complies with requirements specified.
2. Sampling and testing shall be performed by Contractor's testing laboratory. Requirements as specified in Section 01_45_00 - Quality Control.
    a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
    b. Provide full access for Engineer to observe concrete sampling and testing at any time.
    c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory.
    d. Provide firmly braced, insulated, heated, closed wooden curing boxes. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through receipt at Contractor's testing laboratory.
3. Testing shall include:
    a. Sampling of concrete in accordance with ASTM C172.
    b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.
    c. Slump of concrete using slump cone in accordance with the requirements of ASTM C143. Test slump at the following intervals:
        1) Test slump at the beginning of each placement.
        2) As often as necessary to keep slump within the specified range, but not less than every 6th truck.
        3) When requested to do so by the Engineer.
        4) Observe concrete during slump test for signs of segregation:
            a) Observe concrete for mortar or moisture flow from slumped concrete.
            b) Reject concrete if mortar or moisture flows out of the mix.

d. Unit weight of concrete in accordance with ASTM C138.
e. Air entrainment in accordance with ASTM C173. Test air content at the following intervals:
    1) At the beginning of each placement.
    2) As often as necessary to keep entrained air within the specified range, but not less than every 6th truck.
    3) When requested to do so by the Engineer.
f. Compressive strength, f'c, in accordance with ASTM C39. Required number of cylinders:
    1) Not less than 4 cylinder specimens, 4-inch diameter by 8-inches long, will be tested for each 150 cubic yards of each class of concrete; not less than 4 specimens for each half day of placement.
    2) One cylinder will be broken at 7 days and 3 cylinders will be broken at 28 days.

4. Furnish concrete for test specimens and provide manual assistance to testing lab in preparing said specimens.
5. Assume responsibility for providing care and on-site curing and protection for test specimens in accordance with ASTM C31.

## 3.11 FIELD QUALITY CONTROL BY COUNTY

A. Provide on-site observation and field quality assurance for the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Field inspections:
1. Required inspections:
    a. Observe construction for conformance to the Contract Documents and the accepted Submittals.
2. Records of inspections:
    a. Provide record of each inspection.
    b. Submit copies to Contractor upon request.

C. Field tests:
1. Engineer may request, at any time, additional testing to confirm that materials being delivered and placed conform to the requirements of the Specifications.
    a. If such additional testing shows that the materials do not conform to the specified requirements, Contractor shall pay the cost of these tests.
    b. If such additional testing shows that the materials do conform to the specified requirements, Engineer shall pay the cost of these tests.

## 3.12 NON-CONFORMING WORK

A. Enforcement of specification requirements:
1. Do not place concrete that does not conform to the requirements of these Specifications. Remove non-conforming materials from the site.
2. Strength requirements:
    a. Concrete is expected to reach higher compressive strength than the minimum specified compressive strength f'c as indicated in Table B of this Section.

b. Concrete strength will be considered acceptable if following conditions are satisfied:
    1) Averages of all sets of 3 consecutive strength test results are greater than or equal to specified compressive strength f'c.
    2) No individual strength test (average of 2 cylinders tested at 28 days) falls below specified compressive strength f'c by more than 500 pounds per square inch.
c. Whenever one or both of the conditions stated above is not satisfied, provide additional curing or testing of the affected portion as directed by the Engineer.
    1) Costs of such curing or testing shall be at the Contractor's expense.

## 3.13 ADJUSTING

A. Remove and replace or repair defective work as directed by the Engineer:
    1. Do not patch, repair, or cover defective work before observation by the Engineer.
    2. Make no repairs until Engineer has accepted proposed methods for preparation and repair.

END OF SECTION

# SECTION 03_35_29

# CONCRETE FINISHES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Concrete finishes.

### 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117-10 - Specification for Tolerances for Concrete Construction and Materials and Commentary.

B. International Concrete Repair institute (ICRI):
   1. Guideline No. 301.2: Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.

### 1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Grade line: A reference line that separates surfaces considered to be above grade from those considered to be below grade. Located 12 inches below finished grades at the perimeter of the structure.
   2. Water line: A reference line that separates surfaces considered to be above the water level (and visible in the finished work) from those considered to be below the water level (and not visible in the finished work). For each water-bearing cell of a structure, defined as a line located 2 feet below the normal operating water level in that cell.

### 1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Finishing personnel:
      a. Use qualified flatwork finishers.
      b. Finishing supervisor must have at least 5 years of experience finishing concrete.

B. Mockups:
   1. Construct mockup panels showing finishing of formed surfaces for review by the Engineer.
      a. Construct mockup panels demonstrating concrete finishes for vertical surfaces:
         1) Construct mockup panels for F4 and F5 finishes and tie-hole repairs for review by the Engineer.

2. Construct mockup slabs showing finishing of unformed surfaces for review by the Engineer.
    a. Construct mockup slabs demonstrating concrete finishes for horizontal surfaces:
        1) Construct mockup slabs for S1, S2, S4, and S5 finishes.
3. Include the following elements in mockup panels and slabs.
    a. Concrete joints:
        1) Horizontal and vertical joints of the types included in the Work.
    b. Concrete repairs:
        1) Repairs using materials and procedures proposed for the Work.
4. Construct mockup panels and slabs at beginning of project for review by the Engineer.
5. Panels and portions thereof accepted by the Engineer will serve as the standard of quality and workmanship for the Work.

## 1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
    1. Deliver and store packaged materials in original containers until ready for use.

# PART 2 PRODUCTS

## 2.01 MATERIALS

A. Materials for mortar:
    1. As specified in Section 03_30_01 - Concrete Work, unless otherwise noted.
    2. Where finished surfaces will be visible in the finished work, use same cement used for concrete batches in that area. Add white cement if required to obtain color match between base concrete and finishing mortars.

## 2.02 MIXES

A. Cement mortar:
    1. As specified in Section 03_60_00 - Grouting.

B. Dry-pack mortar:
    1. As specified in Section 03_60_00 - Grouting.

C. Mortar mix for F4 finish (“F4 Mortar”):
    1. Consisting of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.

D. Mortar mix for F5 finish (“F5 Mortar”):
    1. Consisting of 1 part cement to 1-1/2 parts of sand passing Number 16 screen.

## 2.03 EVAPORATION RETARDANT

A. As specified in Section 03_30_01 - Concrete Work.

## 2.04 NON-SLIP ABRASIVE

A. Type: Aluminum oxide abrasive of size 8/16, having structure of hard aggregate. Homogeneous, non-glazing, rust-proof, and unaffected by freezing, moisture, and cleaning compounds.

B. Manufacturers: One of the following, or equal:
   1. Abrasive Materials Incorporated, Hillsdale MI.
   2. Exolon Company, Tonawanda NY.

## 2.05 CONCRETE SEALERS

A. Floor sealer and dust-proofer:
   1. Non-membrane forming, breathable, non-yellowing, penetrating sealer designed to densify and seal a cured concrete surface.
   2. Low odor, VOC content of 0 grams per liter, and stable when exposed to ultraviolet radiation from sunlight.
   3. Manufacturers: One of the following, or equal:
      a. Dayton Superior: Day-Chem Sure Hard Densifier (J-17).
      b. Euclid Chemical Company: Euco Diamond Hard.
      c. L&M Construction Chemicals: Seal Hard.
      d. W.R. Meadows: Liqui-Hard.

# PART 3 EXECUTION

## 3.01 CONCRETE FINISHING - FORMED SURFACES

A. Scope:
   1. Finish formed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
   2. Formed surfaces are those surfaces that the plastic concrete is placed against a temporary containment surface that will be removed after the concrete sets and takes its final form.

B. General:
   1. Provide setting and curing time from casting of concrete to removal of forms as specified in Section 03_30_01 – Concrete Work.
   2. Provide curing after removal of forms as specified in Section 03_30_01 – Concrete Work.
   3. Materials and mixes for finishes.
      a. Cement: Add white cement to mortars and grouts used for finishing if required to match color of repairs to surrounding surfaces.
   4. Grinding:
      a. Where grinding of concrete surfaces is permitted:
         1) Perform grinding using an iron-free wheel, such as an aluminum oxide wheel, to avoid entrapment of particles that produce rust stains.
         2) At locations where plastic-protected reinforcing bar supports are used, limit grinding to a maximum depth of 1/16 inch.

C. F1 finish: “Rough Form Finish”:
   1. Repair defective work.
   2. Remove fins and other projections larger than 1/2 inch .
   3. Fill tie holes using dry-pack mortar.
   4. After removal of any curing compounds, fill depressions larger than 1-inch wide or 1/2-inch deep using dry-pack mortar.
   5. Leave surface with texture imparted by forms.
   6. Surface irregularity: Not exceeding a 1-inch gap when measured over the length of a 5-foot straightedge.

D. F2 finish: “Form Finish”:
   1. Repair defective work.
   2. Remove fins and other projections larger than 1/4 inch.
   3. Fill tie holes using dry-pack mortar.
   4. Fill depressions.
      a. Fill after removal of any curing compounds.
      b. Fill depressions larger than 1/2 inch in width or 1/2 inch in depth using cement mortar.
      c. Fill larger voids and depressions, use dry-pack mortar.
   5. Leave surfaces with texture imparted by forms.
   6. Surface irregularity: Not exceeding a 1/4-inch gap when measured over the length of a 5-foot straightedge.

E. F3 finish: “Smooth Form Finish”:
   1. Repair defective work.
   2. Repair rough or irregular surface finishes resulting from failure of form release agent or other form conditions and provide a smooth, uniform surface appearance.
   3. Remove fins: Grind offsets, projections, and rough spots larger than 1/8 inch smooth.
   4. Fill tie holes using dry pack mortar.
   5. Fill depressions:
      a. Fill after removal of any curing compounds.
      b. Fill depressions 1/4 inch and larger in depth or 3/4 inch in width using cement mortar.
      c. For larger depressions, fill using dry pack mortar.
   6. Top coat tie holes and filled depressions with cement mortar to provide uniform appearance.
   7. Leave surfaces with texture that is generally smooth and uniform in appearance.
   8. Surface irregularity: Not exceeding a 1/8 inch gap when measured over the length of a 5-foot straightedge.

F. F4 finish: “Rubbed Finish”:
   1. As specified for F3 finish, except prepare surfaces and fill depressions 1/16 inch or larger in depth or width as follows.
   2. Fill depressions.
      a. “Brush-off” sandblast surfaces to expose all depressions and voids near the surface of the concrete.
      b. Thoroughly wet surfaces and begin filling depressions while surfaces are still damp.

c. Use clean burlap, sponge rubber floats, or trowels to rub plastic F4 mortar over the entire surface to be finished. Fill pits, holes, and depressions.
d. Wipe surfaces clean. Do not leave any mortar on the surface, except that within the depressions.
e. Cure: Moist cure surfaces.

G. F5 finish: “Stoned Finish”:
1. As specified for F3 finish, except add stoned finish as follows:
2. Fill depressions:
a. Wet surfaces thoroughly with brush.
b. Rub wetted surfaces with a hard wood float dipped in water containing 2 pounds of Portland cement per gallon of water.
c. Rub surfaces until form marks and projections are removed.
d. Using a brush, spread plastic grindings from the rubbing operation uniformly over the surface. Work the material in to fill pits and small voids.
e. Cure: Moist cure brushed surfaces for at least 72 hours.
3. Finish surfaces:
a. After curing, obtain final finish by rubbing with a No. 50 grit carborundum stone.
b. Continue rubbing until entire surface has a smooth texture and is uniform in color.
c. Cure: Continue curing for remainder of specified time.
4. Note: If surfaces have become too hard to finish as specified in the preceding paragraphs, the following alternative procedure may be used:
a. Sandblast and wash related surfaces exposed to view, whether finished or not.
b. While surfaces are still damp, rub surface with mortar mix for F5 finish.
c. Finish by rubbing mortared surface with No. 60 grit carborundum stone. Add F5 mortar until surface is evenly filled without excess mortar. Continue stoning until surface is hard.
d. Moist cure surface for 72 hours.
e. After curing, make surface smooth in texture and uniform in color by rubbing with a No. 50 or No. 60 grit carborundum stone.
f. Continue curing until 7-day curing period is complete.

## 3.02 CONCRETE FINISHING - UNFORMED SURFACES

A. Scope:
1. Finish unformed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
2. Unformed surfaces are those surfaces that are not cast against a temporary containment and the specified finish is achieved by tooling.

B. General:
1. Concrete placement:
a. Place concrete at a rate that allows spreading, straight-edging, and initial floating before bleed water appears.
1) Consider characteristics of concrete mixes used, including potential for accelerating or retarding effects of admixtures, fly ash, and temperatures, on plans for and scheduling of placement and finishing.

b. Place, consolidate, strike-off, and screed concrete level to bring surfaces to required planes and lines. Eliminate high and low spots.
c. Strike tops of walls and similar surfaces smooth and finish as specified to a texture consistent with that of adjacent formed surfaces.
d. After screeding, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.

2. Floating and re-straightening:
   a. Float concrete to compact and consolidate the surface.
   b. Initial floating:
      1) Provide initial floating immediately after screeding.
      2) Perform by hand using a wide bull float, darby, or highway straightedge.
      3) Complete before excess moisture or bleed water is present on the surface.
   c. Wait for concrete to stiffen and for the bleed water to stop rising and dissipate before proceeding with edging, hand-tooled jointing, and second floating.
   d. After initial floating, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.
   e. Second floating:
      1) Do not commence until bleed water has dissipated and concrete has stiffened enough to support weight of finishers and finishing equipment.
      2) May be by hand, or, if accepted by the Engineer, may be done using a bladed power float equipped with float shoes, or a power disk float.
      3) Float surfaces to a true, even plane, with no coarse aggregate visible.
      4) Evaporation retardant may not be applied after second floating.
   f. Flatness:
      1) Specified tolerances for flatness may require re-straightening of the surface between first and second floating operations and before steel troweling. Re-straighten concrete as required.
      2) Modify power equipment with alternate float shoes or other equipment if required to achieve specified flatness.

3. Troweling: Where finishes require troweling, conform to the following requirements:
   a. After surface moisture from floating has disappeared, steel trowel to a smooth, hard, dense concrete surface.
   b. Provide at least 2 trowelings.
      1) Avoid excessive troweling.
      2) Use smaller trowels for successive troweling.
      3) Make each successive troweling perpendicular to the previous pass.
   c. Do not add dry cement or additional water to the surface during troweling.
   d. In lieu of hand steel troweling, a power machine for finishing concrete may be used if accepted by the Engineer.
      1) Do not use power machine if concrete has not attained the set necessary to permit finishing without introduction of high and low spots into the concrete surface.

2) Use equipment in full compliance with the manufacturer's recommendations.
3) Use smaller blades or higher pressure for each successive troweling.
4) Hand trowel areas of the concrete not accessible to power equipment.
5) Tolerances for flatness specified may require re-straightening of the surface during finishing. Modify power equipment with alternate shoes or other equipment if required to achieve these requirements.

e. Finishing with a fresno trowel or finishing to a "fresno finish" is not allowed.

4. Finishing tolerances:
   a. Slabs sloped to drain: Finish surfaces to adequately drain toward designated points or lines, regardless of tolerances specified.

C. S1 finish: "Scratch Finish":
1. Place, consolidate, and screed concrete level.
2. Provide initial floating of concrete.
3. Provide surface conforming to the "Conventional" floor flatness tolerance requirements of ACI 117 using the manual straightedge method (maximum 1/2-inch gap in 10 feet at 90 percent of locations; maximum 3/4-inch gap at any location), unless otherwise indicated.
4. Before final set, roughen the surface with rakes.
   a. For sloped surfaces, rake grooves in the direction of drainage.
   b. Provide roughness equivalent to CSP 6 surface as designated by ICRI Guideline 310.2.
5. Pressure wash surface to remove laitance before placing grout or toppings.

D. S2 finish: "Floated Finish":
1. Place, consolidate, and screed concrete to required elevations and slopes.
2. Provide initial and second floatings of concrete. Float to a uniform texture.
3. Provide surface conforming to the "Flat" floor flatness tolerance requirements of ACI 117 using the manual straightedge method (maximum 1/4-inch gap in 10 feet at 90 percent of locations; maximum 3/8-inch gap at any location), unless otherwise indicated.
4. Remove laitance and leave surface clean.

E. S3 finish: "Steel Trowel Finish":
1. Place, consolidate, and screed concrete to required elevations and slopes.
2. Provide S2 Floated Finish.
3. Provide 2 trowelings:
4. Provide finish conforming to the "Flat" floor flatness tolerance requirements of ACI 117 (maximum 1/4-inch gap in 10 feet), unless otherwise indicated.

F. S4 finish: "Steel Trowel Finish - Free of Trowel Marks":
1. Finish as specified for S3 Steel Trowel Finish, except that final troweling shall remove all trowel marks from the slab surface.

G. S5 finish: "Broomed Finish":
1. Finish as specified for S2 Floated Finish, except modify as follows:
2. Finish surface by drawing a fine-hair broom lightly across the freshly floated surface.
   a. Provide resulting roughness for a non-skid surface. Finishing and roughness is subject to review and acceptance by the Engineer.

b. Direction of brooming:
    1) General:
        a) In same direction of and parallel to expansion joints.
        b) Perpendicular to primary direction of traffic.
    2) For sloped slabs, parallel to the direction of drainage.
    3) For round roof slabs, in the radial direction.

H. S6 finish: “Non-Slip Abrasive Finish”:
1. Place, consolidate, and screed concrete to required elevations and slopes.
2. Provide initial floating of surface.
3. Prepare and apply abrasive as recommended by the manufacturer.
    a. Apply using a shake screen or other accepted method to ensure even coverage without segregation of the abrasive.
    b. Install abrasive at a rate of 25 pounds for each 100 square feet of surface area.
4. After concrete has hardened enough to support the weight of a person, and unless otherwise indicated by the abrasive manufacturer, apply approximately 2/3 of the abrasive material required for coverage.
5. Finish as specified for S2 Floated Finish, except that re-floating is not required.
6. Apply remaining abrasive material at right angles to the first application and in locations necessary to provide the minimum specified thickness.
7. Immediately after the second application, re-float the surface to embed abrasive.
8. Finish as specified for S2 Steel Trowel Finish. Trowel abrasive into the surface, properly exposing material to produce a non-slip finish.

## 3.03 FIELD QUALITY CONTROL

A. Provide field quality control for the Work of this Section as specified in Section 01_45_00 - Quality Control.

B. Field quality control by Contractor:
1. Field inspections and testing:
    a. Submit records of inspections and testing to Engineer within 24 hours after completion.
2. Manufacturer's services.
    a. Non-slip abrasive finish. Before beginning installation, conduct pre-installation meeting with manufacturer's technical representative to review product use and installation requirements.

C. Field quality control by County:
1. Special inspections, special tests, and structural observation:
    a. Not required.
2. Field inspections:
    a. Observe construction for conformance to the Contract Documents and the accepted Submittals.
    b. Provide record of each inspection. Submit copies to Engineer upon request.

## 3.04 NON-CONFORMING WORK

A. Unsatisfactory finishes that have hardened will require removal, grinding, topping, or other correction acceptable to the Engineer.

B. Re-work or refinish unsatisfactory finishes at no additional cost to the County.

C. See Section 03_30_01 - Concrete Work for requirements.

## 3.05 SCHEDULE OF CONCRETE FINISHES

A. Formed surfaces: See Table 03_35_29-A.

B. Unformed surfaces: See Table 03_35_29

**Table 03_35_29-A: Concrete Finishes - Formed Surfaces**

| | Elements | Location | Surface Exposure | Finish | Notes |
|---|---|---|---|---|---|
| EXTERIOR SURFACES | Walls<br>Columns<br>Slab edges | Wet structure: | Above grade or water line: | | |
| | | | - Exposed to view | F4 | |
| | | | - Covered | F2 | 1a |
| | | | | | |
| | | | Below grade or water line: | | |
| | | | - No coating | F1 | |
| | | | - Bituminous coating | F2 | |
| | | | - Waterproofing | F3 | |
| | | | | | |
| | | Dry structure: | Above grade line: | | |
| | | | - Exposed to view | F4 | |
| | | | - Covered | F2 | 1a |
| | | | | | |
| | | | Below grade line: | | |
| | | | - No coating | F1 | |
| | | | - Bituminous coating | F2 | |
| | | | - Waterproofing | F3 | |
| | | | | | |

| Table 03_35_29-A: Concrete Finishes - Formed Surfaces | | | | | |
|---|---|---|---|---|---|
| | **Elements** | **Location** | **Surface Exposure** | **Finish** | **Notes** |
| INTERIOR SURFACES | Walls<br>Columns<br>Slab edges | Wet structure: | Open basin: | | |
| | | | - Above water line | F4 | |
| | | | - Below water line | F3 | |
| | | | | | |
| | | | Covered basin | | |
| | | | - Above water line | F3 | |
| | | | - Below water line | F3 | |
| | | | | | |
| | | Dry structure: | Exposed to view | F4 | |
| | | | | | |
| | | | Covered | F2 | 1b |
| | | | | | |
| | Overhead slabs and beams | Wet structure: | Open basin | F3 | 1c, 1d |
| | | | | | |
| | | | Covered basin | F2 | 1d |
| | | | | | |
| | | Dry structure: | Exposed | F3 | 1c, 1d |
| | | | | | |
| | | | Covered by ceiling | F1 | 1d |
| | | | | | |

Notes:
(1a) Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, etc.
(1b) Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, furring strips with drywall, etc.
(1c) Applies to overhead surfaces visible from normal pedestrian travel routes.
(1d) At overhead slabs and beams, patch tie holes on sides of members.

| Table 03_35_29-B: Concrete Finishes - Unformed Surfaces | | | | | |
|---|---|---|---|---|---|
| | **Element** | **Location** | **Exposure** | **Finish** | **Notes** |
| EXTERIOR SURFACES | Footings | Extensions | Exposed | S3 | |
| | | | Covered by soil | S2 | |
| | Slabs and beams - exposed | Walking or possible walking paths | Tops of treatment structures | S5 | 2a, 2b, 2g |
| | | | Stairs & landings | S5 | |
| | | Roofs | Exposed | S5 | |
| | | | Covered by roofing | S2 | |
| | Slabs and beams - submerged | Unless otherwise noted | All | S3 | 2g |
| | Walls, Corbels | Top of wall or corbel | All | S3 | One troweling |
| | | | | | |
| | Sidewalks | All | | S5 | |
| | | | | | |
| | Equipment Slabs | All | | S5 | |
| | | | | | |
| INTERIOR SURFACES | Floor slabs, includes flat and sloping surfaces | Wet structure | Exposed | | |
| | | | - Basins & channels | S3 | |
| | | | | | |
| | | | Covered | | |
| | | | - To receive concrete fill | S1 | 2e |
| | | | | | |
| | | Dry structure | Exposed | | |
| | | | - Pipe galleries | S4 | 2c |
| | | | - Stairs & landings | S4 | 2d |
| | | | - Shops & garages | S4 | |
| | | | - Equipment rooms | S4 | |
| | | | | | |
| | | | Covered | | |
| | | | - Tile on mortar bed | S2 | |
| | | | - Resilient flooring | S3 | |
| | | | - Carpet | S3 | |

Notes:
(2a) Includes slabs covering tanks, basins, channels and similar structures.
(2b) Includes tops of walls or beams that serve as walkways.
(2c) In galleries with slabs subject to wetting, provide broom finish (S5) where indicated on the Drawings.
(2e) Finish for concrete fill: See Floor slab, wet structure, exposed basins and channels.
(2g) Slabs include flat and sloping surfaces.

C. Finish concrete surfaces in accordance with Finish Schedule indicated on the Drawings.

END OF SECTION

# SECTION 03_60_00

# GROUTING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Cement grout.
   2. Cement mortar.
   3. Dry-pack mortar.
   4. Epoxy grout.
   5. Grout.
   6. Non-shrink epoxy grout.
   7. Non-shrink grout.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
   2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   3. C531 - Standard Test Method for Liner Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
   5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

B. International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

### 1.03 SUBMITTALS

A. Cement grout:
   1. Mix design.
   2. Material Submittals.

B. Cement mortar:
   1. Mix design.
   2. Material Submittals.

C. Non-shrink epoxy grout:
   1. Manufacturer's literature.

D. Non-shrink grout:
   1. Manufacturer's literature.

## 1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.

B. Store materials in cool dry place and in accordance with manufacturer's recommendations.

C. Handle materials in accordance with the manufacturer's instructions.

# PART 2 PRODUCTS

## 2.01 MANUFACTURED UNITS

A. Non-shrink epoxy grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star DP Epoxy Grout.
      b. L&M Construction Chemicals, Inc., EPOGROUT.
      c. Master Builder Solutions/Sika, MasterFlow 648.
   2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
   3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
   4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
   5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
   6. Compressive creep: Not exceed 0.0037 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
   7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.

B. Non-shrink grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star Grout.
      b. L&M Construction Chemicals, Inc., CRYSTEX.
      c. Master Builder Solutions/Sika, MasterFlow 928.
   2. In accordance with ASTM C1107.
   3. Preportioned and prepackaged cement-based mixture.

4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
5. Require only addition of potable water.
6. Water for pre-soaking, mixing, and curing: Potable water.
7. Free from emergence of mixing water from within or presence of water on its surface.
8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230.
    a. If at fluid consistency, verify consistency in accordance with ASTM C939.
9. Dimensional stability (height change):
    a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
    b. Have 90 percent or greater bearing area under bases.
10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

## 2.02 MIXES

A. Cement grout:
    1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
    2. Use same materials for cement grout that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
    4. For spreading over surfaces of construction or cold joints.

B. Cement mortar:
    1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
    2. Use same materials for cement mortar that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
    4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.

C. Dry-pack mortar:
    1. Proportions by weight: 1 part Portland cement to 2 parts concrete sand.
        a. Portland cement: As specified in Section 03_30_01 - Concrete Work.
        b. Concrete sand: As specified in Section 03_30_01 - Concrete Work.

D. Epoxy grout:
    1. Consist of mixture of epoxy or epoxy gel and sand.
        a. Epoxy: As specified in Section 03_63_01 - Epoxies.
        b. Epoxy gel: As specified in Section 03_63_01 - Epoxies.
        c. Sand: Clean, bagged, graded, and kiln-dried silica sand.

2. Proportioning:
    a. For horizontal work: Consist of mixture of 1 part epoxy with not more than 2 parts sand.
    b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than 2 parts sand.

E. Grout:
1. Mix in proportions by weight: 1 part Portland cement to 4 parts concrete sand.
    a. Portland cement: As specified in Section 03_30_01 - Concrete Work.
    b. Concrete sand: As specified in Section 03_30_01 - Concrete Work.

F. Non-shrink epoxy grout:
1. Mix in accordance with manufacturer's installation instructions.

G. Non-shrink grout:
1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

### 3.02 PREPARATION

A. Surface preparation for grouting other baseplates:
1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher.
    a. Remove loose or broken concrete.
3. Metal surfaces in contact with grout: Grit blast to white metal surface.

### 3.03 INSTALLATION

A. Mixing:
1. Cement grout:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Dry-patch mortar:
    a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.

4. Non-shrink epoxy grout:
    a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
5. Non-shrink grout:
    a. May be drypacked, flowed, or pumped into place. Do not overwork grout.
    b. Do not retemper by adding more water after grout stiffens.

B. Placement:
1. Cement grout:
    a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
    b. Do not use cement grout that has not been placed within 30 minutes after mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Epoxy grouts:
    a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
4. Non-shrink epoxy grout:
    a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
    b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.
5. Non-shrink grout:
    a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
    b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:
1. Cement based grouts and mortars:
    a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
    b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
2. Epoxy based grouts:
    a. Cure grouts in accordance with manufacturers' recommendations.
        1) Do not water cure epoxy grouts.
    b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids.

E. Grouting other baseplates:
1. General:
    a. Use non-shrink grout as specified in this Section.

b. Baseplate grouting shall take place from 1 side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.

2. Forms and headboxes:
a. Build forms using material with adequate strength to withstand placement of grouts.
b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on 1 side of baseplate.
e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

## 3.04 FIELD QUALITY CONTROL

A. Non-shrink epoxy grout:
1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.

B. Non-shrink grout:
1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION

# SECTION 03_63_01

# EPOXIES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Epoxy.
   2. Epoxy gel.
   3. Epoxy bonding agent.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Systems for Concrete.
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

### 1.03 SUBMITTALS

A. General: Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product Data: Submit manufacturer's data completely describing epoxy materials:
   1. Submit evidence of conformance to ASTM C881. Include manufacturer’s designations of Type Grade, Class, and Color.
   2. Submit documentation that materials meet or exceed the specified strength and performance characteristics. Indicate test methods and test results.

C. Quality control Submittals:
   1. Manufacturer's installation instructions.

## PART 2 PRODUCTS

### 2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Provide epoxy materials that are new.
   2. Store and use products within limitations set forth by manufacturer.
   3. Perform and conduct work of this Section in neat orderly manner.

## 2.02 MATERIALS

A. General:
   1. Moisture tolerant, water-insensitive, two-component epoxy resin adhesive material containing 100 percent solids, and meeting or exceeding the performance properties specified when tested in accordance with the standards specified.

B. Epoxy: Low viscosity product in accordance with ASTM C881; Types I, II, and IV; Grade 1; Class C, except as modified in this Section.
   1. Manufacturers: One of the following, or equal:
      a. Dayton Superior, Unitex Pro-Poxy 100.
      b. Master Builders Solutions/Sika, MasterInject 1380.
      c. Sika Corporation, Sikadur 35 Hi-Mod LV.
   2. Required properties:

**Table 1. Material Properties - Epoxy**

| Property | Test Method | Required Results ("neat") |
|---|---|---|
| Tensile Strength (7-day) | ASTM D638 | 7,000 pounds per square inch, minimum. |
| Compressive Yield Strength (7-day) | ASTM D695 | 10,000 pounds per square inch, minimum. |
| Bond Strength (harded concrete to harded concrete after 2-day cure) | ASTM C882 | 1,000 pounds per square inch, minimum. Concrete failure before failure of epoxy. |
| Viscosity (mixed) | | 250 to 550 centipoise |

Notes:
(1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

C. Epoxy gel: Non-sagging product in accordance with ASTM C881, Types I and IV, Grade 3, Class C.
   1. Manufacturers: One of the following, or equal:
      a. Dayton Superior, Sure Anchor J50.
      b. Master Builders Solutions/Sika, MasterEmaco ADH 327.
      c. Sika Corp., Sikadur 31, Hi-Mod Gel.
   2. Required properties:

**Table 2. Material Properties - Epoxy Gel**

| Property | Test Method | Required Results ("neat") |
|---|---|---|
| Tensile Strength (7-day) | ASTM D638 | 2,000 pounds per square inch, minimum. |
| Compressive Yield Strength (7-day) | ASTM D695 | 8,000 pounds per square inch, minimum. |
| Bond Strength (14-day) | ASTM C882 | 1,500 pounds per square inch, minimum. |

Notes:
(1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

D. Epoxy bonding agent: Non-sagging product in accordance with ASTM C881, Type II, Grade 2, Class C.
   1. Manufacturers: One of the following, or equal:
      a. Dayton Superior, Sure Bond J58.
      b. Master Builders Solutions/Sika, MasterEmaco ADH 326.
      c. Sika Chemical Corp., Sikadur 32 Hi-Mod LPL.
   2. Required properties:

**Table 3. Material Properties - Epoxy Bonding Agent**

| Property | Test Method | Required Results |
|---|---|---|
| Tensile Strength (7-day) | ASTM D638 | 3,300 pounds per square inch, minimum. |
| Compressive Yield Strength (7-day) | ASTM D695 | 8,300 pounds per square inch, minimum. |
| Bond Strength (14-days) | ASTM C882 | 1,800 pounds per square inch, minimum. Concrete failure before failure of epoxy bonding agent. |
| Pot Life | - | Minimum 60 minutes at 100 degrees Fahrenheit. |

Notes:

(1) Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

   3. If increased contact time is required for concrete placement, epoxy resin/Portland cement bonding agent, as specified in Section 03_63_02 - Epoxy Resin/Portland Cement Bonding Agent, may be used instead of epoxy bonding agent.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

B. Epoxy:
   1. Apply in accordance with manufacturer's installation instructions.

C. Epoxy gel:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Use for vertical or overhead work, or where high viscosity epoxy is required.
   3. Epoxy gel used for vertical or overhead work may be used for horizontal work.

D. Epoxy bonding agent:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

## SECTION 03_63_02

## EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Epoxy resin/portland cement bonding agent.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   2. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   3. C496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

B. Federal Highway Administration (FHWA):
   1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

A. Sika Corp., Sika Armatec 110.

B. Substitutions: The use of other than the specified product will be considered, providing the Contractor requests its use in writing to the Engineer. This request shall be accompanied by:
   1. A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds specified performance criteria, tested in accordance with the specified test standards.
   2. Documented proof that the proposed substitute product has a 1-year proven record of performance of bonding portland cement mortar/concrete to hardened portland cement mortar/concrete, confirmed by actual field tests and 5 successful installations that the Engineer can investigate.

### 2.02 MATERIALS

A. Epoxy resin/portland cement adhesive:
   1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

2. Component "B" shall be primarily a water solution of a polyamine.
3. Component "C" shall be a blend of selected portland cements and sands.
4. The material shall not contain asbestos.

## 2.03 DESIGN AND PERFORMANCE CRITERIA

A. Properties of the mixed epoxy resin/portland cement adhesive:
   1. Pot life: 75 to 105 minutes.
   2. Contact time: 24 hours.
   3. Color: Dark gray.

B. Properties of the cured epoxy resin/portland cement adhesive:
   1. Compressive strength in accordance with ASTM C109:
      a. 3 day: 4,500 pounds per square-inch minimum.
      b. 7 days: 6,500 pounds per square-inch minimum.
      c. 28 days: 8,500 pounds per square-inch minimum.
   2. Splitting tensile strength in accordance with ASTM C496:
      a. 28 days: 600 pounds per square-inch minimum.
   3. Flexural strength:
      a. 1,100 pounds per square-inch minimum in accordance with ASTM C348.
   4. Bond strength in accordance with ASTM C882 modified at 14 days:
      a. 0 hours open time: 2,800 pounds per square-inch minimum.
      b. 24 hours open time: 2,600 pounds per square-inch minimum.
   5. The epoxy resin/portland cement adhesive shall not produce a vapor barrier.
   6. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA-RD-86-193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.

# PART 3 EXECUTION

## 3.01 INSTALLATION

A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low-speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only the quantity that can be applied within its pot life.

B. Placement procedure:
   1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper-type" spray equipment:
      a. For hand applications: Place fresh plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
      b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

C. Adhere to all limitations and cautions for the epoxy resin/portland cement adhesive in the manufacturer's current printed literature.

## 3.02 CLEANING

A. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

## SECTION 05_05_24

## MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.
      b. Sleeve anchors.
      c. Screw anchors.
   3. Appurtenances for anchoring and fastening:
      a. Anchor bolt sleeves.
      b. Isolating sleeves and washers.
      c. Thread coating for threaded stainless steel fasteners.

## 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.

B. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

C. ASTM International (ASTM):
   1. A29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for.
   2. A36 - Standard Specification for Carbon Structural Steel.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   4. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   5. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   6. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   7. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   9. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   10. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plan and Deformed, for Concrete.

11. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
12. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
13. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
14. F436 - Standard Specification for Hardened Steel Washers.
15. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
16. F594 - Standard Specification for Stainless Steel Nuts.
17. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
18. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

## 1.03 DEFINITIONS

A. Built-In Anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.

B. Cast-In Anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

C. Overhead Installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.

D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

E. Post-Installed Anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.

F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
1. Corrosive locations: Describes interior and exterior locations as follows:
    a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
2. Wet and moist locations: Describes locations, other than "corrosive locations," that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
    a. Exterior portions of buildings and structures.
    b. Liquid-containing structures:
        1) Locations at and below the maximum operating liquid surface elevation.

2) Locations above the maximum operating liquid surface elevation and:
a) Below the top of the walls containing the liquid.
b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).

c. Liquid handling equipment:
1) Bases of pumps and other equipment that handles liquids.

d. Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.

e. Other locations indicated on the Drawings.

3. Other locations:
a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

## 1.04 SUBMITTALS

A. General:
1. Submit as specified in Section 01_33_00 - Submittal Procedures.
2. Submit information listed for each type of anchor or fastener to be used.

B. Action submittals:
1. Product data:
a. Cast-in anchors:
1) Manufacturer's data including catalog cuts showing anchor sizes and configuration, materials, and finishes.

b. Post-installed anchors:
1) For each anchor type, manufacturer's data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.

2. Samples:
a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.

3. Certificates:
a. Cast-in anchors:
1) Mill certificates for steel anchors that will be supplied to the site.

b. Post-installed anchors:
1) Manufacturer's statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.

4. Test reports:
a. Post-installed anchors: For each anchor type used for the Work:
1) Current ICC-ES Report (ESR ), or equivalent acceptable to the Engineer and the authority having jurisdiction, demonstrating:
a) Acceptance of that anchor for use under the building code specified in Section 01_41_00 - Regulatory Requirements.

5. Manufacturer's instructions:
a. Requirements for storage and handling.

b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
c. Requirements for inspection or observation during installation.

6. Qualification statements:
   a. Post-installed anchors: Installer qualifications:
      1) Submit list of personnel performing installations and include date of manufacturer's training for each.

## 1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Post installed anchors shall be in accordance with building code specified in Section 01_41_00 - Regulatory Requirements.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.

B. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.

C. Protect anchors from weather and moisture until installation.

# PART 2 PRODUCTS

## 2.01 MANUFACTURED UNITS

A. General:
   1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
      a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
      b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
   2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
   3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

B. Materials:
   1. Provide and install anchors of materials as in this Section.

## 2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Description:
      a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
      b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
         1) Rods or bars with angle bend for embedment in concrete (i.e., “L” or “J” shaped anchor bolts) are not permitted in the Work.
   2. Materials:
      a. Ship anchor bolts with properly fitting nuts attached.
      b. Type 316 stainless steel:
         1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
         2) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
         3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
         4) Washers: Type 316 stainless steel.
      c. Type 304 stainless steel:
         1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
         2) Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
         3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
         4) Washers: Type 304 stainless steel.
      d. Galvanized steel:
         1) Hot-dip galvanized coating in accordance with ASTM F2329.
         2) Bolt: ASTM F1554, Grade 36, heavy hex, coarse thread.
         3) Nuts: ASTM A563, Grade A, heavy hex, threads to match bolt.
         4) Washers: ASTM F436, Type 1.

## 2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE

A. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

## 2.04 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL

A. General:
   1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01_41_00 - Regulatory Requirements. Reports prepared by other recognized evaluation agencies may be submitted for consideration if acceptable to the Engineer and to the authority having jurisdiction.
      a. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:

1) In regions of concrete where cracking has occurred or may occur.
2) To resist short-term loads due to wind forces.
3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.

2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
   a. Calculations shall be prepared by and shall bear the signature and seal of a Professional Engineer licensed in the State of Florida.
   b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.

B. Concrete anchors:
   1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing, friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
   2. Concrete anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
         2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
      b. Manufacturers: One of the following or equal:
         1) Hilti, Kwik Bolt TZ Expansion Anchor.
         2) DEWALT/Powers, PowerStud.
         3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.
      c. Materials. Integrally threaded stud, wedge, washer, and nut:
         1) Stainless steel: Type 316.
            a) Type 304 stainless steel acceptable for use at wet and moist locations when accepted in writing by the Engineer.
         2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

C. Flush shells:
   1. Description: Post-installed anchor assembly consisting of an internally threaded mandrel that is forced into a pre-drilled concrete hole with a setting tool until the top of the anchor is flush with the face of the concrete. Once installed, a removable threaded bolt is installed in the mandrel.
   2. Flush shell anchors are not permitted in the Work.

D. Sleeve anchors:
   1. Description: Post-installed, torque-controlled anchor assembly consisting of an externally threaded stud with a spacer sleeve near the surface of the base material, and an expansion sleeve on the lower part of the stud. The expansion sleeve is forced outward by torquing of the center stud to transfer load.
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.
   2. Sleeve anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Sleeve anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
         2) Sleeve anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
      b. Manufacturers: One of the following or equal:
         1) Hilti, HSL-3 Heavy Duty Expansion (sleeve) Anchor.
         2) DEWALT/Powers, Power Bolt+ Heavy Duty Sleeve Anchor.
      c. Materials:
         1) Stainless steel: Not available.
         2) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

E. Screw anchors:
   1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creating a helical "key" that is larger than the diameter of the bolt itself along the length of the anchor shaft.
   2. Screw anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Screw anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
         2) Screw anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
      b. Manufacturers: Screw anchor: One of the following or equal:
         1) Hilti, Hex head, HUS-EZ Screw Anchor:
            a) With internally threaded head: HUS-EZ I Hanger Anchor.
         2) DEWALT/Powers, Screwbolt+ Screw Anchor:
            a) With internally threaded head: Vertigo+ Rod Hanging System.
         3) Simpson Strong-Tie, Titen® HD Screw Anchor:
            a) With internally threaded head: Titen® HD Rod Hanger.

c. Materials:
1) Stainless steel
2) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5) or equal.

## 2.05 APPURTENANCES FOR ANCHORING AND FASTENING

A. Anchor bolt sleeves:
1. Having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long.
2. Plastic sleeves:
a. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
b. Manufacturers: The following or equal:
1) Portland Bolt & Manufacturing Co.
3. Fabricated steel sleeves:
a. Fabricate to the following dimensions unless otherwise indicated on the Drawings:
1) Inside diameter: At least 2 inches greater than bolt diameter.
2) Inside length: Not less than 10 bolt diameters.
3) Bottom plate:
a) Square plate with dimensions equal to the outside diameter of the sleeve plus 1/2 inch each side.
b) Thickness equal to or greater than one-half of the anchor bolt diameter.
b. Carbon steel anchor bolts:
1) Fabricated from ASTM A36 plate and ASTM A53, Grade B pipe.
2) Welded connections: Conform to requirements of AWS D1.1.
3) Hot dip galvanized in accordance with ASTM A153.
c. Stainless steel anchor bolts:
1) Fabricated from ASTM A240 plate and pipe. Type 304L or Type 316L to match Type of the anchor bolt.
2) Welded connections: In accordance with AWS D1.6.

B. Forged steel hardware:
1. See Section 05_12_00 - Structural Steel for forged steel hardware connectors, including clevises, turnbuckles, eye bolts, eye nuts, and sleeve nuts.

C. Isolating sleeves and washers:
1. Manufacturers: One of the following or equal:
a. Central Plastics Co.
b. Allied Corrosion Industries.
2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
3. One sleeve required for each bolt.
4. Washers: The inside diameter of all washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter.
a. Proper size to fit bolts.
b. Two 1/8-inch thick steel washers for each bolt.

c. G3 Phenolic: 2 insulating washers are required for each bolt:
    1) Thickness: 1/8 inch.
    2) Base material: Glass.
    3) Resin: Phenolic.
    4) Water absorption: 2 percent.
    5) Hardness (Rockwell): 100.
    6) Dielectric strength: 450 volts per mil.
    7) Compression strength: 50,000 pounds per square inch.
    8) Tensile strength: 20,000 pounds per square inch.
    9) Maximum operating temperature: 350 degrees Fahrenheit.

D. Coating for repair of galvanized surfaces:
    1. Manufacturers: The following or equal:
        a. Jelt, Galvinox.

E. Thread coating: For use with threaded stainless steel fasteners:
    1. Manufacturers: One of the following or equal:
        a. Bostik, Never-Seez.
        b. Oil Research, Inc., WLR No. 111.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### 3.02 INSTALLATION: GENERAL

A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.

B. Substitution of anchor types:
    1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
    2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.

C. Protect products from damage during installation. Take special care to protect threads and threaded ends.

D. Accurately locate and position anchors and fasteners:
    1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
    2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.

E. Interface with other products:
   1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
   2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

## 3.03 INSTALLATION: CAST-IN ANCHORS

A. General:
   1. Accurately locate cast-in and built-in anchors.
      a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
      b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
      c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
      d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
   2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
   3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.

B. Anchor bolts:
   1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
   2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment. Fill sleeves with grout when a machine or other equipment is grouted in place.

## 3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS

A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

## 3.05 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS

A. General:
   1. Install anchors in accordance with the manufacturer’s instructions, ACI 355.2, the anchor’s ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.

2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
3. After anchors have been positioned and inserted into concrete or masonry, do not:
    a. Remove and reuse/reinstall anchors.
    b. Loosen or remove bolts or studs.

B. Holes drilled into concrete and masonry:
1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f'c or f'm).
2. Accurately locate holes:
    a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
    b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
    a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer's instructions before proceeding.
4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
5. Drill using anchor manufacturer's recommended equipment and procedures:
    a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
        1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
        2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.
6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.
7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor.
    a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
    b. Repeat cleaning process as required by the manufacturer's installation instructions.
    c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

C. Insert and tighten (or torque) anchors in full compliance with the manufacturer's installation instructions.
1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.

D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

| Concrete Anchors | | | |
|---|---|---|---|
| Nominal Diameter | Minimum Effective Embedment Length | | Minimum Member Thickness |
| | In Concrete | In Grouted Masonry | |
| 3/8 inch | 2 1/2 inch | 2 5/8 inch | 8 inch |
| 1/2 inch | 3 1/2 inch | 3 1/2 inch | 8 inch |
| 5/8 inch | 4 1/2 inch | 4 1/2 inch | 10 inch |
| 3/4 inch | 5 inch | 5 1/4 inch | 12 inch |

E. Flush shell anchors:
   1. Flush shell anchors are not permitted in the Work.
   2. If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact Engineer for instructions before proceeding.

F. Sleeve anchors:
   1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

| Sleeve Anchors | | | |
|---|---|---|---|
| Nominal Diameter | Minimum Effective Embedment Length | | Minimum Member Thickness |
| | In Concrete | In Grouted Masonry | |
| M8 (1/2 inch) | 70 mm (2 3/4 inch) | Not accepted | 100 mm (8 inch) |
| M10 (5/8 inch) | 76 mm (3 inch) | Not accepted | 250 mm (10 inch) |
| M12 (3/4 inch) | 80 mm (3 1/4 inch) | Not accepted | 300 mm (12 inch) |

   2. Install with the sleeve fully engaged in the base material.

G. Screw anchors:
   1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

| Screw Anchors | | | |
|---|---|---|---|
| Nominal Diameter | Minimum Effective Embedment Length | | Minimum Member Thickness |
| | In Concrete | In Grouted Masonry | |
| 3/8 inch | 2 1/2 inch | 3 1/4 inch | 8 inch |
| 1/2 inch | 3 1/4 inch | 4 1/2 inch | 8 inch |
| 5/8 inch | 4 inch | 5 inch | 10 inch |
| 3/4 inch | 5 1/2 inch | 6 1/4 inch | 12 inch |

   1. Install screw anchors using equipment and methods recommended by the manufacturer. Continue driving into hole until the washer head is flush against the item being fastened.

## 3.06 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section as specified in Section 01_45_00 - Quality Control.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.

B. Post-installed anchors:
   1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.
   2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
   3. Certify in writing to the Engineer that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

## 3.07 FIELD QUALITY ASSURANCE

A. County provide on-site observation and field quality assurance for the Work of this Section.
   1. Expenses associated with work described by the following paragraphs shall be paid by the County.

B. Field inspections and special inspections:
   1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted submittals, and manufacturer's installation instructions for the products used.
   2. Record of inspections:
      a. Maintain record of each inspection.
      b. Submit copies to Engineer upon request.
   3. Statement of special inspections: At the end of the project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.

C. Special inspections: Anchors cast into concrete and built into masonry.
   1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
      a. Anchor bolts.
   2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents.
      a. Anchor:
         1) Type and dimensions.
         2) Material: Galvanized steel, Type 304 stainless steel, or Type 316 stainless steel as specified in this Section or indicated on the Drawings.
         3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.

4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.

3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
   a. Base material (concrete or grouted masonry):
      1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
      2) Material encapsulating embedment is dense and well-consolidated.

D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
   1. Provide special inspection during installation of the following anchors:
      a. Concrete anchors.
      b. Sleeve anchors.
      c. Screw anchors.
   2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
      a. Provide continuous special inspection for post-installed anchors in "overhead installations" as defined in this Section.
   3. Requirements for periodic special inspection:
      a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
         1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new "initial inspection."
      b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor's rated strength.
      c. Anchor:
         1) Manufacturer, type, and dimensions (diameter and length).
         2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
      d. Hole:
         1) Positioning: Spacing and edge distances.
         2) Drill bit type and diameter.
         3) Diameter, and depth.
         4) Hole cleaned in accordance with manufacturer's required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
         5) Anchor's minimum effective embedment.
         6) Anchor tightening/installation torque.
   4. Requirements for continuous special inspection:
      a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.

E. Field tests:
   1. County may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
      a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
      b. If such additional testing shows that the materials do conform to the specified requirements, the County shall pay the costs of these tests.

## 3.08 NON-CONFORMING WORK

A. Remove misaligned or non-performing anchors.

B. Fill empty anchor holes and repair failed anchor locations as specified in Section 03_60_00 – Grouting using high-strength, non-shrink, non-metallic grout.

C. If more than 10 percent of all tested anchors of a given diameter and type fail to achieve their specified torque or proof load, the Engineer will provide directions for required modifications. Make such modifications, up to and including replacement of all anchors, at no additional cost to the County.

## 3.09 SCHEDULES

A. Stainless steel. Provide and install stainless steel anchors at the following locations:
   1. “Corrosive locations” as defined in this Section: Type 316 stainless steel.
   2. “Wet and moist locations” as defined in this Section: Type 316 stainless steel.
   3. “Other locations:”
      a. For connecting steel or stainless steel members to concrete or masonry: Type 304 stainless steel.
      b. For connecting aluminum members to concrete or masonry.
      c. For connecting fiber-reinforced plastic (FRP) members to concrete or masonry.
   4. At locations indicated on the Drawings.

B. Galvanized: Provide and install galvanized carbon steel anchors at the following locations:
   1. Locations not requiring stainless steel.
   2. At locations indicated on the Drawings.

END OF SECTION

## SECTION 05_12_00

## STRUCTURAL STEEL FRAMING

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Structural steel shapes and plate.
   2. Fasteners and structural hardware:
      a. All thread rods.
      b. Forged steel structural hardware.
      c. High-strength bolts.
   3. Welding.
   4. Bolting.

## 1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
   2. 360 - Specification for Structural Steel Buildings.

B. American Iron and Steel Institute (AISI):
   1. Steel and stainless steel alloys (“types”) as indicated.

C. American Welding Society (AWS):
   1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
   2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
   3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
   4. D1.1 - Structural Welding Code - Steel.
   5. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
   2. A36 - Standard Specification for Carbon Structural Steel.
   3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   7. A276 - Standard Specification for Stainless Steel Bars and Shapes.

8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
9. A489 - Standard Specification for Carbon Steel Lifting Eyes.
10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
12. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
13. A992 - Standard Specification for Structural Steel Shapes.
14. B695 – Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
15. F436 - Standard Specification for Hardened Steel Washers.
16. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
17. F594 - Standard Specification for Stainless Steel Nuts.
18. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
19. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. Research Council on Structural Connections (RCSC):
1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

## 1.03 DEFINITIONS

A. Snugtight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

B. Stainless steel related terms:
1. Descaling: Removal of heavy, tightly adherent oxide films resulting from hot-forming, heat-treatment, welding, and other high-temperature operations.
2. Pickling: Chemical descaling of stainless steel using aqueous solutions of nitric and hydrofluoric acid, or various proprietary formulations as specified.
3. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel’s protective passive film.

## 1.04 SUBMITTALS

A. Product data:
1. Welding electrodes: Electrode manufacturer's data.
2. Stainless steel: Fabricator name and qualifications, member dimensions and structural section properties, and specifications and procedures used for pickling and passivating members.

B. Shop drawings:
   1. Fabrication and erection drawings.

C. Quality control submittals:
   1. Welding procedure specifications (WPS) in accordance with AWS D1.1.
      a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing.
         1) State electrode manufacturer and specific electrodes used.
         2) Indicate required AWS qualification for joint.
      b. Submit WPS with shop drawings that indicate those welds.
      c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.1 for welding procedures qualified by testing.
   2. Welder qualifications: For each welding process and position:
      a. Welder's qualification certificates.
      b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.1.
   **3.** Test reports:
   3. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

## 1.05 QUALITY ASSURANCE

A. Welding:
   1. Perform welding of structural metals in accordance with AWS D1.1 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.
   2. Make Welding Procedure Specifications available at the locations where welding is performed.
   3. Notify Engineer at least 24 hours before starting shop or field welding.
   4. Engineer may check materials, equipment, and qualifications of welders.
   5. Remove welders performing unsatisfactory Work, or require requalification.
   6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
   7. Contractor shall bear costs of retests on defective welds.
   8. Contractor shall also bear costs in connection with qualifying welders.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.

B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

## PART 2 PRODUCTS

### 2.01 MATERIALS

A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:

| Item | ASTM Standard | Class, Grade, Type, or Alloy Number |
|---|---|---|
| **Carbon Steel** | | |
| Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items | A36 | -- |
| Rolled W and WT shapes | A992 | Grade 50 |
| Hollow structural sections/HSS: Round, square, or rectangular (including “pipe” where indicated for structural members and supports) | A500 | Grade C |
| Stainless steel | | |
| Plate, sheet, and strip | A240 | Type 304* or 316** |
| Bars and shapes | A276 | Type 304* or 316** |
| * Use Type 304L (low-carbon stainless steel) if material will be welded. | | |
| ** Use Type 316L (low carbon stainless steel) if material will be welded. | | |

### 2.02 FASTENERS AND STRUCTURAL HARDWARE

A. General:
   1. Materials: Of domestic manufacture.
   2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.

B. All thread rods:
   1. Carbon steel:
      a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.
      b. Nuts: ASTM A194.
      c. Washers: ASTM F436.
   2. Galvanized carbon steel:
      a. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.
      b. Nuts: ASTM A194, hot-dip galvanized in accordance with ASTM A153.
      c. Washers: ASTM F436, hot-dip galvanized in accordance with ASTM A153.

C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

D. Forged steel structural hardware - carbon steel:
   1. Clevises and turnbuckles: Forged steel in accordance with AISI C-1035.
   2. Eye nuts / Eye bolts: Forged steel in accordance with AISI C-1030.
      a. Having geometric and strength characteristics (including proof load, breaking strength, tensile strength, bend test, and impact strength) of eyebolts in accordance with ASTM A489, Type 1.
   3. Sleeve nuts: Forged steel in accordance with AISI C-1018 Grade 2.

E. High-strength bolts:
   1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators. Provide uncoated components unless galvanized coating is indicated on the Drawings.
   2. Carbon steel - Uncoated:
      a. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1**.**
      b. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
      c. Washers:
         1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1. Flat circular washers unless otherwise indicated on the Drawings.
         2) Adjacent to long slotted holes: Fabricated from 5/16-inch thick plate conforming to ASTM A36.
      d. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
         1) Compressible washer type direct tension indicators (“DTI”): In accordance with ASTM F959, Type 325-1.
         2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852.
   3. Carbon steel - Galvanized:
      a. Bolt and nut assemblies fabricated, galvanized, tested for rotational capacity, and shipped accordance with the provisions ASTM F3125, Grade A325 and the RCSC Specification.
      b. Bolts, nuts, and washers: Hot-dip galvanized in accordance with ASTM F2329.
      c. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1 and galvanized as specified.
      d. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade DH, galvanized as specified, and lubricated in accordance with ASTM A563, Supplementary Requirement S1 to minimize galling.
      e. Washers:
         1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1 and galvanized as specified. Flat circular washers unless otherwise indicated on the Drawings.
         2) Adjacent to long slotted holes: 5/16-inch thick plate washer fabricated from steel conforming to ASTM A36, and galvanized in accordance with ASTM A123.

f. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
   1) Compressible washer type direct tension indicators (“DTI”): In accordance with ASTM F959, Type 325-1, with mechanically deposited zinc coating conforming to ASTM B695, Class 55.
   2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852 with mechanically deposited zinc coating conforming to ASTM B695, Class 55.

F. Stainless steel bolts (for use in stainless steel structures):
   1. General:
      a. Bolts and nuts shall be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship bolts with properly fitting nuts attached.
      b. Units descaled, pickled and passivated as specified in “Fabrication."
   2. Alloy: Type 304 or Type 316 to match alloy of structural members being connected.
   3. Type 304:
      a. Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
      b. Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
      c. Washers: Type 304 stainless steel.
   4. Type 316:
      a. Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
      b. Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
      c. Washers: Type 316 stainless steel.

## 2.03 ISOLATING SLEEVES AND WASHERS

A. As indicated on the Drawings and as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## 2.04 GALVANIZED SURFACE REPAIR

A. Manufacturers: The following or equal:
   1. Jelt, Galvinox.

## 2.05 THREAD COATING

A. Manufacturers: One of the following or equal:
   1. Bostik, Never-Seez.
   2. Oil Research, Inc., WLR No. 111.

## 2.06 SUPPLEMENTARY PARTS

A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

## 2.07 FABRICATION

A. Shop assembly:
   1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
   3. Round off sharp and hazardous projections and grind smooth.
   4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
   5. Take responsibility for correct fitting of metalwork.
   6. Welded connections:
      a. Comply with AWS requirements for the metals to be welded.
      b. Weld only in accordance with approved Welding Procedure Specifications.
      c. Keep Welding Procedure Specifications readily available for welders and inspectors during fabrication processes.

B. Stainless steel shapes and assemblies:
   1. For structural members such as W shapes, S shapes, channels, angles, and similar rolled shapes not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
      a. Fabricate shapes using laser-fused, full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as that of members indicated on the Drawings.
      b. Fabricate shapes from dual grade stainless steel.
      c. Fabricate beams and channels to ASTM A6 tolerances.
      d. Manufacturers: The following or equal:
         1) Stainless Structural, LLC.
   2. Cleaning and passivation:
      a. Following shop fabrication of stainless steel members and bolts, clean and passivate fabrications at point of manufacture.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a bright passive finished surface with no etching, pitting, frosting, or discoloration.
      c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
         1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
      d. Pre-clean, chemically de-scale (“pickle”), passivate, and final-clean fabrications in accordance with the requirements of ASTM A380.
         1) If degreasing is required before cleaning (pickling) to remove scale or iron oxide, cleaning with citric acid treatments is permissible; however, such treatments shall be followed inorganic cleaners.
         2) Pickle and passivate stainless steel using a nitric acid solution in accordance with ASTM A380, Annex A2, Table A2.1, Part II.

3) Pickling by citric acid treatment or sulfuric acid treatment is not considered to satisfy the requirements of this Section.

e. Inspect after cleaning using methods specified for “gross inspection” in ASTM A380.

f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the site.

C. Galvanized carbon steel:

1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A123:
2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
3. Re-straighten galvanized items that bend or twist during galvanizing.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

### 3.02 ERECTION

A. General:

1. Fabricate structural and foundry items to true dimensions without warp or twist.
2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
9. Round off sharp or hazardous projections and grind smooth.
10. Paint or coat steel items as specified in Section 09_96_01 - High-Performance Coatings.

B. Stainless steel. Take all necessary precautions to avoid iron contamination of stainless steel during delivery, storage, and handling.

1. Segregate stainless steel from iron.

2. Tools and handling devices.
    a. Do not use iron tools clamps, chokes, working surfaces, or brushes when fabricating, handling, and erecting stainless steel.
    b. Do not use tools that have been contaminated by contact with iron.
    c. Use stainless steel, polymer coated, or wood tools and handling equipment. Do not use tools that have been contaminated by contact with iron or steel.

C. Welding: General:
    1. Make welds full penetration type, unless otherwise indicated on the Drawings.
    2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

D. Welding: Carbon steel:
    1. General: In accordance with AWS D1.1:
        a. Weld ASTM A36 and A992 structural steel, and ASTM A500 and A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:
        b. Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

E. Interface with other products:
    1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.

F. Fasteners: General:
    1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
    2. Anchor bolts and anchor rods: Install as specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
        a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snugtight" condition.
    3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03_21_17 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

G. Fasteners: High-strength carbon steel bolts:
    1. Connections with high-strength bolts shall in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
    2. Provide pre-tensioned joints at bolted connections, except where slip-critical or snugtight connections are indicated on the Drawings.
    2. Joints: Slip-critical.
        a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
        b. Furnish hardened flat washers in accordance with ASTM F436:
            1) On outer plies with slotted holes.

2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
3) Under element, nut, or bolt head, turned in tightening.

c. Install tension indicator washers, placed in accordance with ASTM F959 Figure X1, to confirm adequate tightening of bolts.
d. Tighten bolts to full pretension.

3. Joints: Pre-tensioned.
   a. Joint preparation, assembly, and tightening shall be as specified for slip-critical connections, except that the requirements for un-coated faying surfaces shall not apply.
5. Joints: Snugtight:
   b. Install bolts with washers where required in accordance with RCSC Specification.
   c. Tighten bolts to bring the connected plies into firm contact. Tightening shall progress systematically beginning with the most rigid part of the joint. More than 1 cycle through the bolt pattern may be required to achieve this condition.
   d. Verify adequate tightening of bolts by visual observation to confirm that washers have been installed at locations required in accordance with RCSC Specification, and that the plies of the connected parts have been brought into firm contact.

H. Fasteners: Stainless steel bolts:
   1. Connections shall be snugtight joints unless otherwise indicated on the Drawings.
   2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.
   3. Rotate nuts using a slow, smooth action without interruptions. Avoid over-tightening.

## 3.03 FIELD QUALITY CONTROL

A. Provide quality control as specified in Section 01_45_00 - Quality Control.

## 3.04 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01_45_00 - Quality Control.

END OF SECTION

## SECTION 07_92_00

## JOINT SEALANTS

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Precast concrete joint sealant.
   3. Silicone sealant.
   4. Synthetic rubber sealing compound.
   5. Synthetic sponge rubber filler.
   6. Related materials.

## 1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. ASTM International (ASTM):
   1. C920 - Standard Specification for Elastomeric Joint Sealants.
   2. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
   3. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   4. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
   5. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   6. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

## 1.03 SUBMITTALS

A. Product data.

B. Samples, include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.

## 1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

## 1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

## 1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

## 1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

# PART 2 PRODUCTS

## 2.01 SEALANTS

A. General:
   1. Provide colors matching materials being sealed.
   2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
   3. Nonsagging sealant for vertical and overhead horizontal joints.
   4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
   5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
   6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
      a. Control joint depth.
      b. Break bond of sealant at bottom of joint.
      c. Provide proper shape of sealant bead.
      d. Serve as expansion joint filler.

## 2.02 ACRYLIC-LATEX SEALANT

A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by Engineer from manufacturer's standard options:
   1. Manufacturers: One of the following or equal:
      a. Tremco, Tremflex 834.
      b. Pecora Corp., Number AC-20.
      c. Sonneborn, Sonolac.

## 2.03 PRECAST CONCRETE JOINT SEALANT

A. Preformed, cold-applied, ready-to-use, flexible joint sealant in accordance with ASTM C990 and AASHTO M 198:
   1. Manufacturers: One of the following or equal.
      a. Henry Corp., Ram-Nek.
      b. Concrete Sealants Division, ConSeal.

## 2.04 SILICONE SEALANT

A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant:
   1. Manufacturers: One of the following or equal:
      a. Tremco, Proglaze.
      b. Pecora Corp., Number 864.
      c. Dow Corning, Number 795.
      d. General Electric, Number 1200 Series.

## 2.05 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
   1. Sika Corporation, Sikaflex 2c NS EZ Mix.
   2. Pacific Polymers, Elastothane 227R.

B. Material: In accordance with ASTM C920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
   1. Base: Polyurethane rubber.
   2. Application time: Minimum 2 hours.
   3. Cure time: Maximum 3 days.
   4. Tack free time: Maximum 24 hours.
   5. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
   6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.
   7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
   8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.

9. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

## 2.06 SYNTHETIC SPONGE RUBBER FILLER

A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C:
   1. Manufacturers: The following or equal:

B. Presstite, No. 750.3 Ropax Rod Stock.Characteristics:
   1. Suitable for application intended.
   2. Strength: As necessary for supporting sealing compound during application.
   3. Resiliency: Resistance to environmental conditions of installation.
   4. Bonding: No bonding to the sealing compound.
   5. Structure: Cellular, prevents absorption of water.
   6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
   7. Size: Minimum 25 percent greater than nominal joint width.

## 2.07 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

# PART 3 EXECUTION

## 3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

## 3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
   1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
   2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
   1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
   2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
   1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
   2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less than 3/8 inches deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.

J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

## 3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.
   3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.
   4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
   5. Complete caulking prior to painting.
   6. Verify that concrete is thoroughly cured prior to caulking.
   7. When filler compressible material is used, use untreated type.
   8. Apply caulking with pneumatic caulking gun.

9. Use nozzles of proper shape and size for application intended.
10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

## 3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.

## 3.05 SCHEDULE

A. Acrylic latex:
   1. Use where indicated on the Drawings.
   2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.

B. Silicone:
   1. Use where indicated on the Drawings.
   2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
   3. Door threshold bedding.
   4. Moist or wet locations, including joints around plumbing fixtures.
   5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
   6. Plenum joints.

C. Synthetic rubber sealing compound, non-sag Type II:
   1. Use where indicated on the Drawings.
   2. Water-bearing and earth-bearing concrete structures.
   3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.
   4. Joints between sheet metal flashing and trim.
   5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
   6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
   7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
   8. Expansion and control joints in masonry vertical surfaces.

D. Synthetic rubber sealing compound, self-leveling Type I:
   1. Use where indicated on the Drawings.
   2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
   3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
   4. Pavement joints.
   5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

## 3.06 FIELD QUALITY CONTROL

A. Adhesion testing:
   1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
      a. Water bearing structures: 1 test per every 1,000 LF of joint sealed.
      b. Exterior precast concrete wall panels: 1 test per every 2,000 LF of joint sealed.
      c. Chemical containment areas: 1 test per every 1,000 LF of joint sealed.
      d. Building expansion joints: 1 test per every 500 LF of joint sealed.
      e. All other type of joints except butt glazing joints: 1 test per every 3,000 LF of joint sealed.
      f. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

**SECTION 09_96_01**

**HIGH-PERFORMANCE COATINGS**

**TABLE OF CONTENTS**

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

### 1.02 REFERENCES

A. Abbreviations:
   1. CMU - Concrete masonry units.
   2. CSA - Coating system applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.
   3. CSM - Coating system manufacturer.
   4. CTR - Coating system manufacturer's technical representative.
   5. DFT - Dry-film thickness. Thickness of cured film, usually expressed in mils (0.001 inch).
   6. VOC - Volatile organic compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.
   7. WFT - Wet film thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

B. Standards:
   1. ASTM International (ASTM):
      a. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
      b. D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
      c. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
      d. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
      e. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
      f. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
      g. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
      h. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
      i. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
      j. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
      k. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
      l. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.

m. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
n. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
o. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
p. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.

2. International Concrete Repair Institute (ICRI):
   a. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
3. NACE International (NACE):
   a. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
   b. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. National Association of Pipe Fabricators (NAPF):
   a. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
5. NSF International (NSF):
   a. 61 - Drinking Water System Components - Health Effects.
6. Occupational Safety and Health Administration (OSHA).
7. Society of Protective Coatings (SSPC):
   a. Glossary - SSPC Protective Coatings Glossary.
   b. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
   c. PA 1 - Shop, Field, and Maintenance Painting of Steel.
   d. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   e. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
   f. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
   g. SP 1 - Solvent Cleaning.
   h. SP 3 - Power Tool Cleaning.
   i. SP 5 - White Metal Blast Cleaning.
   j. SP 10 - Near-White Metal Blast Cleaning.
   k. SP 11 - Power Tools Cleaning to Bare Metal.
   l. SP 13 - Surface Preparation of Concrete.
   m. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   n. SP COM - Surface Preparation Commentary.
   o. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
   p. SP WJ-1 - Waterjet Cleaning of Metals—Clean to Bare Substrate.
   q. SP WJ-2 - Waterjet Cleaning of Metals—Very Thorough Cleaning.
   r. SP WJ-3 - Waterjet Cleaning of Metals—Thorough Cleaning.
   s. SP WJ-4 - Waterjet Cleaning of Metals—Light Cleaning.

## 1.03 TERMINOLOGY

A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.

B. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
   3. Anchor Pattern: Profile or texture of prepared surface(s).
   4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
   5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
   6. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
   7. Dew point: Temperature a given air/water vapor mixture starts to condense.
   8. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
   9. Dry to Touch: Time interval between material application and its ability to tolerate a light touch without coating damage.
   10. Drying Time: Time interval between application and material curing.
   11. Exposed Surface: Any indoor or outdoor surface not buried or encased.
   12. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
   13. Feathering: Tapering off a wet edge with a comparatively dry brush.
   14. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
   15. Field Coat: Application of a surface coating system at the work site.
   16. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
   17. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
   18. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
   19. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
   20. Hydroblast: High or ultra-high-pressure water jet surface preparation.
   21. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
   22. Incompatibility: One coating’s inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
   23. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
   24. Mil: 0.001 inch.
   25. Overspray: Dry spray, particularly paint bonded to an unintended surface.

26. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.
27. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
28. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.
29. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
30. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
31. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
32. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
33. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
34. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
35. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
36. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

## 1.04 SUBMITTALS

A. As specified in Section 01_33_00 - Submittal Procedures, submit the following:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.
   3. Dehumidification and heating plan.

4. Product data:
    a. Physical properties of coatings, including the following:
        1) Solids content.
        2) Ingredient analysis.
        3) VOC content.
        4) Temperature resistance.
        5) Typical exposures and limitations.
        6) Manufacturer's standard color chips.
    b. Compliance with regulatory requirements:
        1) VOC limitations.
        2) Lead compounds and polychlorinated biphenyls.
        3) Abrasives and abrasive blast cleaning techniques and disposal.
        4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
        5) NSF certification of coatings for potable water supply systems.
    c. CSM's current printed recommendations and product datasheets for coating systems, including:
        1) Surface preparation recommendations.
        2) Primer type.
        3) Maximum dry and wet-mil thickness per coat and number of coats.
            a) Coating coverage worksheets.
        4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
        5) Curing time before submergence in liquid.
        6) Thinner to be used for each coating.
        7) Ventilation requirements.
        8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
        9) Allowable application methods.
        10) Maximum allowable substrate moisture content.
        11) Maximum shelf life.
        12) Requirements for transportation and storage.
        13) Mixing instructions.
        14) Shelf life.
        15) Material Pot life.
        16) Precautions for applications free of defects.
        17) Method of application.
        18) Drying time of each coat, including prime coat.
        19) Compatible prime coats.
        20) Limits of ambient conditions during and after application.
        21) Required protection from sun, wind, and other conditions.
        22) Touch-up requirements and limitations.
        23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.
    d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
    e. Affidavits signed by an officer of the CSM’s corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.
    f. List of cleaning and thinner solutions allowed by the CSMs.

g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
h. Thick film coating systems (greater than 25 mils):
1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
2) Include detail treatment for coating system at concrete joints.
3) Manufacturer's Representative's (CTR) Field Reports.

5. Quality assurance Submittals:
a. Quality assurance plan.
b. Qualifications of CSA, including:
1) List of Similar Projects.
a) Name and address of project.
b) Year of installation.
c) Year placed in operation.
d) Point of contact: Name and phone number.
2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
c. CSA Reports:
1) Written daily quality control inspection reports.
d. CTR Reports:
1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
2) Reports on visits to project site to observe and approve coating application procedures.
3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

## 1.05 QUALITY ASSURANCE

A. CSA qualifications:
1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:
a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.
2. SSPC-QP 1 certified.
3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.

B. CTR qualifications:
1. Certification, one of the following:
a. NACE Level 2 or 3 Certified Coating Inspector.
b. SSPC Level 3 Protective Coatings Inspector.
2. Minimum of 5 years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
a. Provide CTR qualifications and references listing 5 similar projects completed in the past 5 years.

C. Regulatory requirements: Comply with governing agencies' regulations by using coatings in accordance with to their VOC limits.
   1. Lead-based coatings are not permitted.
   2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

D. Pre-installation conference: Conduct as specified in Section 01_31_19 - Project Meetings.
   1. Coordinate Hold Point schedule.

E. Field samples:
   1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
   2. Approved field sample may be part of the Work.

F. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

G. CSM services:
   1. CSA shall arrange for CTR to attend pre-installation conferences.
   2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
   3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
   4. CTR shall provide written inspection reports.

H. Quality control requirements:
   1. Contractor shall be responsible for the workmanship and quality of the coating system installation.
      a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor's responsibilities.
   2. In accordance with this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
   3. Specially trained crews with experience applying the specified coating system coating are required for:
      a. Coating application using plural component spray equipment or other specialty equipment.
      b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
   4. CTR shall specially train personnel for coating systems as specified in Attachment B - Coating Detail Sheets.
      a. CSM shall approve personnel in writing applying the coating system.
   5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
   6. Identify inspection access points used by Owner's or Engineer's personnel.
   7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer's personnel to safely access the work areas.

8. Conduct and continually inspect work so the coating system is installed as specified. CSM shall provide written directions to correct coating work not in accordance with the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
    a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
        1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
        2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
    b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
        1) ASTM D4262.
        2) ASTM D4263.
        3) ASTM D4417.
        4) ICRI 310.2 requirements.
        5) SSPC Surface Preparation Standards.
    c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
    d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
    e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
    f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc., during coating.
        1) Perform WFT measurements in accordance with ASTM D4414.
    g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces.
        1) Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM’s written instructions.
        2) Perform applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

I. Inspection at Hold Points:
    1. Conduct inspections at Hold Points during the coating system application and record the results.
    2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor’s inspections on a scheduled basis.
    3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.

4. Hold Points shall be as follows:
    a. Conditions before surface preparation: Before starting surface preparation, observe, record, and confirm that oil, grease, and/or soluble salts are gone from the surface.
    b. Post surface preparation: After completing surface preparation, measure and inspect for cleanliness and proper surface profile as specified in this Section and in the CSM’s written instructions.
    c. Coatings application: At the beginning of any coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
    d. Post application inspection: Identify defects in application work on all surfaces, including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness, and other problems.
    e. Follow-up corrective actions and final inspection: Measure and re-inspect corrective coating work performed to repair defects at prior Hold Points and repeat until the surface condition is acceptable. Conduct final visual inspection with follow-up tests, such as holiday detection, adhesion tests, and DFT surveys.
    f. Coatings application: At the beginning of coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
        1) Observe conditions during the pre-application meeting.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01_60_00 - Product Requirements.

B. Immediately remove unspecified and unapproved coatings from Project site.

C. Deliver new labeled, unopened containers:
1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM’s recommendations.
    a. Store flammable materials in accordance with federal, state, and local requirements.
    b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
3. Container labels shall show the following:
    a. Brand name or product title.
    b. CSM's batch number.
    c. CSM's manufacture date.
    d. CSM's name.
    e. Generic material type.
    f. Application and mixing instructions.

g. Hazardous material identification label.
h. Shelf life expiration date.
i. Color.
j. Mixing and reducing instructions.

4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

## 1.07 PROJECT CONDITIONS

A. Apply coatings to dry surfaces.
1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section.
a. Plaster and gypsum wallboard: 12 percent.
b. Masonry and concrete block: 12 percent.
c. Interior located wood: 15 percent.
d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.

B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
3. When ambient or surface temperature:
a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
b. Is less than 65 degrees Fahrenheit for clear finishes unless manufacturer allows a lower temperature.
c. Exceeds 90 degrees Fahrenheit unless manufacturer allows a higher temperature.
d. Exceeds manufacturer's recommendation.
4. When relative humidity is higher than 85 percent.
5. Under dusty or adverse environmental conditions.
6. When light on surfaces measures less than 15 foot-candles.
7. When wind speed exceeds 15 miles per hour.

C. Apply coating only under evaporation conditions rather than condensation.
1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
a. Submit test results.

D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
   1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
   2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
   3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
   4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
   5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
      a. Entire curing period.
      b. 8 hours after coating.

E. Systems:
   1. Site electrical power availability.
   2. Internal combustion engine generators may be used.
      a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
      b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
      c. Locate engine generator outside hazardous classified areas in accordance with NFPA 820.
      d. Provide daily fuel service for generator for duration of use.
   3. Dehumidification:
      a. Provide desiccant or refrigeration drying.
      b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
      c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
   4. Heating:
      a. Use electric, indirect combustion, or steam coil.
      b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
   5. Filters:
      a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment’s ability to control dew point and relative humidity inside the reservoir.
      b. Do not allow air from the working area or dust filtration equipment to recirculate through thein dehumidifier during coating application or when solvent vapors are present.
   6. Design and Submittals:
      a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
      b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.

F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

## 1.08 MAINTENANCE

A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

B. Provide extra materials:
   1. Minimum 1 gallon of each type and color of coating applied or provide additional quantities if specified in the Contract Documents:
      a. Deliver unopened factory-labeled cans when manufacturer packages material in gallon cans.
      b. Deliver material in new gallon containers, properly sealed and identified with permanently affixed, durable, printed labels indicating brand, type, and color, when manufacturer does not package material in gallon cans, deliver.

## 1.09 CTR RESPONSIBILITIES

A. General:
   1. Attend pre-installation conference.
   2. Perform onsite application training.
   3. Periodically inspect coating system application.

B. Coating system installation training:
   1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
      a. Train a minimum of 2 supervisory personnel and 2 application personnel.
      b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
   2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
   3. Minimum training requirements:
      a. Explain in detail the mixing, application, curing, and termination requirements.
      b. Provide hands-on demonstration of coating system mixing.
      c. Explain in detail the ambient condition requirements for temperature and humidity.
      d. Explain in detail the surface preparation requirements.
      e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
      f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
   4. Provide special training as specified in the Coating Detail Sheets.

C. Coating system inspection:
   1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
   2. Be on-site to oversee:
      a. Coating application at least once a week.
      b. End of surface preparation.
      c. During coating application.

d. Post-cure inspection.

3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
4. Perform the following activities to confirm conformance with the specifications:
   a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
   b. Inspect each coated surface type and coating system applied to verify the following:
      1) Cleanliness.
      2) Surface pH for concrete substrates.
      3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
   c. Verify surface profile of substrates by completing the following:
      1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
      2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
      3) Verify proper mixing of coating materials.
      4) Inspect application of primers and finish coats, including wet and dry film thickness.
      5) Inspect coating systems for proper cure times and conditions.
   d. Review adhesion testing of cured coating systems.
   e. Review coating system continuity testing.
   f. Inspect and record representative-localized repairs.
   g. Conduct final review of completed coating system installation.
   h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM's Recommendations.

D. Final report:
   1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs.
      a. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits.
      b. Include a statement that completed work was performed in accordance with the requirements of the CSM's recommendations.

## PART 2 PRODUCTS

### 2.01 DESIGN AND PERFORMANCE CRITERIA

A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.

B. Coating materials that come in contact with water distributed as potable water shall be certified in accordance with NSF 61.

## 2.02 MATERIALS

A. General:
   1. Product requirements: As specified in Section 01_60_00 - Product Requirements.

## 2.03 COATING SYSTEMS IDENTIFICATION

A. Naming conventions: Coating Systems Identifications contain the elements defined in Table 1.

**Table 1. Coating System Identification Elements**

| **First Element** | **-** | **Second Element** | **-** | **Third Element** | **-** | **Fourth Element (optional)** |
|---|---|---|---|---|---|---|
| 3 or 4 alpha characters | | 1-3 alpha characters | | 1 number | | 3 or 4 alpha characters |
| Coating Type | | Substrate | | System Number | | Additional Substrate or Special Condition |
| Example: EPX | - | C | - | 6 | - | BSC |

   1. First element identifies the coating type using the following abbreviations:
      a. ACR: Acrylic.
      b. CTE: Coal tar epoxy.
      c. ELA: Elastomeric acrylic.
      d. EPU: Epoxy-polyurethane.
      e. EPX: Epoxy.
      f. POL: Polyurethane.
      g. SIL: Silicone.
      h. SILX: Siloxane or silane.
      i. VE: Vinyl ester.
   2. Second element identifies the substrate using the following abbreviations:
      a. C: Concrete or masonry.
      b. F: Concrete flooring.
      c. FRP: Fiber-reinforced plastic.
      d. GM: Galvanized metal.
      e. M: Metal.
      f. PVC: Polyvinyl chloride, chlorinated polyvinyl chloride.
   3. Third element identifies the sequential system number.
      a. For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.
   4. Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
      a. PWS: Potable water service applications (NSF-61 approved).
      b. BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
      c. BG: Below grade or buried.
      d. OZ: Organic zinc primer, epoxy polyurethane system.
      e. SC: Secondary containment.

## 2.04 PRODUCTS FOR COATING SYSTEMS

A. Products: As specified in Attachment B - Coating Detail Sheets.

B. Cleaning solvents:
   1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
      a. Emulsifying type.
      b. Containing no phosphates.
      c. Biodegradable.
      d. Does not damage zinc.
      e. Compatible with the specified primer.
      f. Complying with applicable air-quality control board requirements.
   2. Use clean white cloths and clean fluids in solvent cleaning.

## PART 3 EXECUTION

### 3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.

B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.

C. Mask off surfaces of items not to be coated or remove items from area.

D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.

F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application.
   1. Carefully store, clean, and replace items after completing coating in each area.
   2. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

G. Erect and maintain protective enclosures in accordance with SSPC-Guide 6.

H. Protect the following surfaces from abrasive blasting by masking or by other means:
   1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
   2. Machined surfaces for sliding contact.
   3. Surfaces to be assembled against gaskets.
   4. Surfaces of shafting where sprockets will be fit.
   5. Surfaces of shafting where bearings will be fit.
   6. Machined bronze surfaces, including slide gates.
   7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
   8. Galvanized items, unless scheduled to be coated.

I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.

J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces.
   1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
   2. After completing coating, reinstall removed items.
   3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

## 3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.

B. Coating detail sheets in Attachment B - Coating Detail Sheets include additional surface preparation requirements.

C. Follow more stringent requirements if information conflicts.

D. Where required by the Owner’s representative, a NACE International certified coatings inspector, provided by the Engineer, will inspect and approve surfaces to be coated before applying a coating.
   1. CSA shall coordinate coating inspections.
      a. Identify coating inspection Hold Points during the pre-installation conference.
      b. Provide at least 2 days' notice before inspection.
   2. Correct surface defects identified by the inspector at no additional cost to the Owner.

## 3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit.

B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.

C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and top coats, as applicable, and color selected by the Owner.

D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

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

## 3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
   1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
   2. Manufacturers: The following or equal:
      a. CHLOR*RID International, Inc.
         1) Complete soluble salt removal with steam or warm water cleaning.
   3. Steam clean and degrease surfaces to be coated to remove oils and grease.
   4. Clean surfaces with decontamination agent in conjunction with abrasive blast cleaning, steam cleaning, high-pressure washing, or hand washing, as approved by the CTR and the Engineer.
   5. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
   6. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

## 3.05 BLAST CLEANING

A. Surface preparation requirements:
   1. Do not reuse spent blast abrasive.
   2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil.
      a. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply.
      b. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
   3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
   4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.

5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.
7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.

B. Water jetting or water blasting:
1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
2. Perform water jetting or water blasting in accordance with SSPC-SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

## 3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

A. Cure for at least 28 days before coating.

B. Remove degraded concrete using abrasive blast cleaning or high or ultra-high-pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove bruised or cracked concrete.

C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges in accordance with the CSM's recommendations, and as indicated on the Drawings.
1. Prepare concrete surfaces in accordance with SSPC-SP 13.

D. Prepare concrete surfaces in accordance with SSPC-SP 13.
1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
3. Repair concrete defects and physical damage.
4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
5. Fill voids to provide surface as specified in Section 03_35_29 - Concrete Finishes.

E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.

2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.

F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
   1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.
   2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.

H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.

I. Vacuum concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
   1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
   2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.

J. Test moisture content of concrete to be coated:
   1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
      a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
   2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
   3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
      a. Waterproof surfaces exposed to soil or water.
   4. Comply with specified minimum moisture content and CSM’s written recommendations for moisture vapor transmission rates or relative humidity values.

K. Masonry surfaces:
   1. Cure for at least 28 days before coating.
   2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
   4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
   5. Confirm that masonry surfaces are dry before coating application.
      a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

## 3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

A. Remove rust, scale, and welding slag and spatter.
   1. Remove and grind smooth excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.
   2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
   1. Remove grease and oil in accordance with SSPC-SP 1.
   2. Use solvent as recommended by the CSM.
   3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Select blast particle size and gradation to produce the specified surface profile.
   4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no “rust back” occurs before coating material application.

C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner's representative to inspect on the first day of cleaning.

D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
   1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
   2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
   3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
   4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.

E. Field preparation of shop-primed surfaces:
   1. Smooth welds and prominences with power tools before applying field-applied coatings.
   2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
   3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
      a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
   4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
   5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).

F. Damaged shop primer or rust bleeding:
   1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
   2. Reject galvanized steel with rust bleeding.

G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

## 3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Galvanized steel and non-ferrous metal surfaces:
   1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
   2. Abrasive blast clean in accordance with SSPC-SP 16.
      a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3 (Power Tool Cleaning).
   3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
   4. Test surface for contaminants using copper sulfate solution.

B. Stainless-steel surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.

C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

D. Sherardized, aluminum, copper, and bronze surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16.
   2. Prepare in accordance with CSM's instructions.

E. Cadmium-plated, zinc-plated, or sherardized fasteners:
   1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.

F. PVC and FRP surfaces:
   1. Lightly sand surfaces to be coated.
      a. Sand to remove gloss and establish uniform surface profile.
   2. Vacuum to remove loose dust, dirt, and other materials.
   3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

## 3.09 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. Mechanical equipment shop primed by the manufacturer.
    1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications.
        a. Provide CTR shop coating reports.
    2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
        a. If project requires equipment removal and reinstallation, complete touch-up coating after final installation.
    3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.

D. Verify surface preparation immediately before applying coating in accordance with SSPC-SP COM and the SSPC visual standard for the specified surface preparation method.

E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

G. Do not apply coatings to a surface until it has been prepared as specified.

H. Use equipment designed to apply materials specified.
    1. Use compressors with moisture traps and filters that remove water and oils from the air.
        a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
    2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
    1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.

J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications.
    1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
    2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
    3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or top coats are applied.

K. Spray application:
    1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.

2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.

M. Remove dust on coatings between coats.

N. Shop and field coats:
1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
    a. Provide datasheets identifying the shop primer to on-site coating application personnel.
    b. Perform adhesion tests on the shop primer.
    c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
    d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.
2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
    a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
    a. Prime coat adheres to the substrate.
    b. Coatings adhere to the prime and intermediate coats.
        1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
        2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.

O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

P. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
2. Before starting application:
    a. Verify gauges are working properly.
    b. Complete ratio checks.
    c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
    d. Label and retain spray samples. Submit to Engineer when requested.

Q. Drying and recoating:
   1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
   2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM's printed instructions, before recoating.
   3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time.
      a. Do not allow excessive drying time or exposure, which may impair bond between coats.
      b. Recoat coatings within time limits recommended by CSM.
      c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
   4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.
   5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
   6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
   7. Leave no holidays. Repair holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.
   8. Sand and feather into a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.

R. Workmanship:
   1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
   2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
   3. Remove splatter and droppings after coating work is completed.
   4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
   5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
   6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
      a. Brush apply stripe coat to ensure proper coverage.
      b. Do not stripe coat with spray or roller.
   7. Ensure that finish coat, including repairs, has a uniform color and gloss.

S. Coating properties, mixing, and thinning:
   1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
   2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures in accordance with CSM's instructions.

3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
5. Mix coatings with 2 or more components in accordance with CSM's instructions.
6. Where necessary to suit conditions of the surface, temperature, weather, and method of application, thin the coating in accordance with CSM's recommendations.
    a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
    b. Thin coatings to only what is necessary to obtain proper application characteristics.
    c. Use a thinner recommended by the CSM.

T. Film thickness and continuity:
1. Apply coating to the specified thicknesses.
    a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.
2. Verify WFT of the coating system first coat and after applying each subsequent coat.
3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
    a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.

U. Protecting coated surfaces:
1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.

V. Special requirements:
1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
3. Areas damaged during erection:
    a. Prepare surface for spot repairs as specified for the coating system.
    b. Recoat with prime coat before applying subsequent coats.
    c. Touch up surfaces after installation.
    d. Clean and dry surfaces to be coated at time of application.
4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.

5. Coat aluminum in contact with concrete.

## 3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
   1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.

B. Apply surfacer or filler and let dry before coating application.
   1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions.
      a. Let concrete substrate dry before applying filler/surfacers or coating system materials.
   2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures in accordance with CSM's instructions.
   3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system.
      a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
      b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
      c. Provide relatively flat, uniformly even surface before coating application.
   4. Secondary containment: Place surfacer or filler 1/16-inch thick above concrete plane to create a monolithic surface free of pinholes.
      a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
      b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.

C. Concrete substrate temperatures:
   1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
      a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
   2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
      a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
      b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.

D. Perform application detail work in accordance with these Specifications, the CSM’s current written recommendations, and Drawings, whichever is stricter.

E. Concrete coating systems application requirements:
   1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

## 3.11 COATING SYSTEM SCHEDULE

A. Attachment A - Schedule of Surfaces to be Coated specifies surfaces to be coated in the field with the coating systems required.

## 3.12 SURFACES NOT REQUIRING COATING

A. Stainless steel piping, valves, pipe supports, instrument sunshades.

B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.

C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

D. Copper and brass pipe, fittings, valves, etc.

E. Bronze valves, bearings, bushings, and fasteners.

F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

G. Exterior concrete.

H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.

I. Buried piping that is encased in concrete or cement mortar.

## 3.13 QUALITY CONTROL

A. Owner-provided inspection or inspection by others does not limit the Contractor’s or CSA’s responsibilities for quality workmanship or quality control as specified or as required by the CSM’s instructions. Owner inspection is in addition to any inspection required of the Contractor.

B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
   1. Inspect materials upon receipt to ensure that the CSM supplied them.
   2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   3. Inspect and record findings for substrate cleanliness.
   4. Inspect and record pH of concrete and metal substrates.
   5. Inspect and record substrate profile (anchor pattern).
   6. Measure and record ambient air and substrate temperature.
   7. Measure and record relative humidity.
   8. Check for substrate moisture in concrete.

9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
11. Perform adhesion testing.
12. Measure and record the coating system's thickness.
13. Verify proper curing of the coating system in accordance with the CSM's instructions.
14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.

C. Perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
   1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
   2. Coated concrete.
   3. Perform holiday tests after proper application and coating system cure.

## 3.14 CORRECTIVE MEASURES

A. Repair pinholes or holidays identified by Holiday Testing as follows:
   1. Remove the coating system with a grinder or other suitable power tool.
   2. Remove coating system at pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
   3. Concrete voids: Chip back to expose entire cavity in all directions.
      a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool and strike off. Cure in accordance with CSM's recommendations.
   4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
   5. Vacuum the prepared area to remove dust, dirt, etc., leaving clean, sound surfaces.
   6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
   7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
   8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast in accordance with CSM's instructions if the maximum recoat time is exceeded.
   9. Apply coating at specified dry film thickness.

## 3.15 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

## 3.16 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with the Engineer to ensure Work is in accordance with Contract Documents requirements.

C. Mark any rework required.
   1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

## ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT A
Schedule of Surfaces to be Coated

A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

| | |
|---|---|
| EPU-M-1 | Metals, exterior, non-immersed |
| EPX-M-2-PWS | Metals: immersed and in contact with water being treated for domestic use (potable water). |
| EPX-F-1 | 0 |
| ACR-PVC-1 | Floors |

Notes:

1: Non-immersed ferrous metal surfaces include:
- a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing.
- b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
- c. Motors and motor accessory equipment.
- d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment.
- e. Valve and gate operators and stands.
- f. Structural steel.
- g. Crane and hoist rails.
- h. Exterior of tanks and other containment vessels.
- i. Mechanical equipment supports, drive units, and accessories.
- j. Bare electrical equipment: boxes, exposed conduit, and accessories.
- k. Pumps not submerged.
- l. Other miscellaneous metals.

2: Immersed ferrous metal surfaces include:
- a. Interior surfaces of ferrous metal tanks.
- b. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service.
- c. Bell rings, underside of manhole covers and frames.
- d. Sump pumps, including underside of base plates and submerged suction and discharge piping.
- e. Exterior of submerged piping and valves other than stainless steel or PVC piping.
- f. Submerged pipe supports and hangers.
- g. Stem guides.
- h. Other submerged iron and steel metal unless specified otherwise.

**ATTACHMENT B**

| Attachment B | | | |
|---|---|---|---|
| Coating Detail Sheet | | | |
| | | | |
| Coating System | EPU-M-1 | | |
| Coating Material | Two coats epoxy with polyurethane finish coat | | |
| Substrate | Metal | | |
| Products: One of the following or equal: | Primer | Intermediate Coat | Finish Coat |
| Carboline | Carboguard 890 | Carboguard 890 | Carbothane 134 VOC |
| International Paint | Devran 224V | Devran 224V | Devthane 379 |
| PPG | Amercoat 385 | Amercoat 385 | Amercoat 450H |
| Sherwin Williams | Macropoxy 646 | Macropoxy 646 | Hi Solids Polyurethane |
| Tnemec | Series 69 | Series 69 | Series 1095 |
| | | | |
| | | | |
| Service Condition | Interior or Exterior, subject to direct sunlight. Non-immersion. | | |
| | | | |
| Surface Preparation | | | |
| General | Prepare surfaces as specified in this Section and as follows. | | |
| Ferrous Metal | Bare surfaces: SSPC-SP10, Near-White Blast Cleaning.<br>Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning.<br>Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime. | | |
| Nonferrous Metal | SSPC-SP16, Brush Blast Cleaning. | | |
| Galvanized Metal | SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants. | | |
| | | | |
| Surface profile | | | |
| Ferrous Metal | 2.5 to 3.0 mils | | |
| Nonferrous Metal | 1.5 to 2.0 mils | | |
| Galvanized Metal | 1.5 to 2.0 mils | | |
| | | | |
| System Thickness (Dry Film) | | | |
| Total | 10 to 13 mils | | |
| Primer | 4 to 5 mils | | |
| Intermediate Coat | 4 to 5 mils | | |
| Finish Coat | 2 to 3 mils | | |
| | | | |
| Application | | | |
| Special CTR Training | Not required. | | |

| Attachment B | | | |
|---|---|---|---|
| Coating Detail Sheet | | | |
| | | | |
| Coating System | EPX-M-2-PWS | | |
| Coating Material | Ultra-high Solids Epoxy | | |
| Substrate | Metal | | |
| Products: One of the following or equal: | Primer | Intermediate Coat | Finish Coat |
| Carboline | Plasite 4500 | None Applied | Plasite 4500 |
| International Paint | No product specified | No product specified | No product specified |
| PPG | No product specified | No product specified | No product specified |
| Sherwin Williams | Sher-Plate | None Applied | Sher-Plate |
| Tnemec | Series 22 | None Applied | Series 22 |
| | | | |
| | | | |
| Service Condition | Immersed, moderately corrosive environment in contact with Potable Water. | | |
| | | | |
| Surface Preparation | | | |
| General | Prepare surfaces as specified in this Section and as follows. | | |
| Ferrous Metal | Bare surfaces: SSPC-SP5, White Metal Blast Cleaning.<br>Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning.<br>Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime. | | |
| | | | |
| Surface profile | | | |
| Ferrous Metal | 2.0 to 2.5 mils | | |
| Primed surfaces | 1.0 to 1.5 mils on the intact primer. | | |
| | | | |
| System Thickness (Dry Film) | | | |
| Total | 16 to 25 mils | | |
| | | | |
| Application | | | |
| Special CTR Training | Required. | | |

| Attachment B | | | |
|---|---|---|---|
| Coating Detail Sheet | | | |
| **[Contact Mike Dadik for more info.]** | | | |
| Coating System | EPX-F-1 | | |
| Coating Material | Epoxy Resin Based Floor Coating | | |
| Substrate | Concrete Floors | | |
| Products: One of the following or equal: | Primer | Intermediate Coat | Finish Coat |
| Carboline | Flow Prime | Peran STC | Peran STC |
| PPG | Megaseal HSPC | Megaseal SL | Megaseal SLClear |
| Sherwin Williams | GP-3579 | GP-3579 with broadcast if required | GP-3745 |
| Stonhard | Stonhard Standard Primer | Broadcoat | Stoneshield Sealer |
| Tnemec | Series 238 | Series 238 with Broadcoat | Series 284 Clear |
| | | | |
| | | | |
| Service Condition | Interior light duty applications light wheel traffic, mostly foot traffic, and mildly corrosive. Mainly for wear resistance, aesthetics, and cleanability. Non-slip texture can be varied depending on wetness of exposure. Test patches to be installed for deciding level of non-slip texture. | | |
| | | | |
| Surface Preparation | | | |
| General | Prepare surfaces as specified in this Section and as follows. | | |
| Concrete | Let concrete floor slabs age for at least 28 days and ensure that a moisture vapor transmission rate of less than 3.0 lbs per 24 hours per 1,000 SF in accordance with ASTM F1869 is met. Keep the vapor barrier well sealed and intact and installed beneath all slabs on grade to receive this floor coating system. Remove loose concrete, curing compounds, and laitance with abrasive blast cleaning or, preferably, with shot blasting, unless specified otherwise. Produce a clean, sound concrete substrate with a concrete surface profile of CSP 6 minimum in accordance with ICRI 310.2. Prepare surfaces in accordance with SSPC-SP13. Prepare all coating termination and transition details in accordance with CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, pipe penetration treatment, coating terminations at metal embedments in the concrete substrate, and other details. Submit the CSM's standard detail drawings for all such coating applications. CSM shall produce detail drawings at no additional cost to the Owner, the Engineer, or other party if drawings are not available.<br>Let concrete substrate dry under warm conditions (minimum of 75 degrees F) for at least 5 days before coating application if using wet abrasive or water blasting surface preparation methods. In such cases, the moisture vapor transmission requirements must be met. Vacuum all surfaces to be coated to remove loose dirt, dust, or other loose materials after preparing surface. | | |
| | | | |
| Surface profile | | | |
| Concrete | ICRI CSP SP-6. | | |
| Existing Coated Concrete | ICRI CSP SP-6. | | |
| | | | |
| System Thickness (Dry Film) | | | |
| Total | 125 mils | | |
| Primer | Brush or roller apply at 6.0-10.0 mils | | |
| Intermediate Coat | 110-125 mils | | |
| Finish Coat | Brush or roller apply at 6.0-10.0 mils | | |
| Application | | | |
| Special CTR Training | Required. | | |

| Attachment B | | | |
|---|---|---|---|
| Coating Detail Sheet | | | |
| | | | |
| Coating System | ACR-PVC-1 | | |
| Coating Material | Acrylic | | |
| Substrate | PVC and CPVC pipe | | |
| Products: One of the following or equal: | Primer | Intermediate Coat | Finish Coat |
| Carboline | Carbocrylic 120 | None Applied | Carbocrylic 3359 |
| International Paint | Devcryl 1440 | None Applied | Devcryl 1448 |
| PPG | Pitt Tech Primer | None Applied | Pitt Tech |
| Sherwin Williams | Sher Cryl HPA | None Applied | Sher Cryl HPA |
| Tnemec | Series 1028 or 1029 | None Applied | Series 1028 or 1029 |
| | | | |
| | | | |
| Service Condition | Exterior, exposed to direct sunlight, non-immersed. | | |
| | | | |
| Surface Preparation | Prepare surfaces as specified in this Section and as follows. | | |
| General | Clean to remove loose dirt, dust, or other contaminants.<br>Sand surfaces to achieve a uniform, roughened surface profile.<br>Solvent clean and vacuum to remove loose debris. | | |
| Surface profile | 1.5 to 2.0 mils | | |
| | | | |
| System Thickness (Dry Film) | | | |
| Total | 4 to 8 mils | | |
| Primer | 2 to 4 mils | | |
| Finish Coat | 2 to 4 mils | | |
| | | | |
| Application | | | |
| Special CTR Training | Not Required. | | |

## SECTION 26_05_02

## BASIC ELECTRICAL REQUIREMENTS

## PART 1 GENERAL

### 1.01 RELATED SECTIONS

A. Requirements specified within this section apply to all sections in Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

### 1.02 DESIGN REQUIREMENTS

A. All electronic boards as part of electrical equipment shall meet the atmospheric conditions of the space the equipment is installed in. All electronic boards which are not installed in a conditioned environment shall be fungus-resistant.

B. All electrical equipment shall be rated for the conditions the equipment is installed in.

### 1.03 STANDARDS, CODES, PERMITS, AND REGULATIONS

A. Perform all work; furnish and install all materials and equipment in full accordance with the latest applicable rules, regulations, requirements, and specifications of the following:
   1. Local Laws and Ordinances.
   2. State and Federal Laws.
   3. National Electrical Code (NEC).
   4. State Fire Marshal.
   5. Underwriters' Laboratories (UL).
   6. National Electrical Safety Code (NESC).
   7. American National Standards Institute (ANSI).
   8. National Electrical Manufacturer's Association (NEMA).
   9. National Electrical CONTRACTOR'S Association (NECA) Standard of Installation.
   10. Institute of Electrical and Electronics Engineers (IEEE).
   11. Insulated Cable Engineers Association (ICEA).
   12. Occupational Safety and Health Act (OSHA).
   13. National Electrical Testing Association (NETA).
   14. American Society for Testing and Materials (ASTM).
   15. Florida Building Code, including local County amendments.

B. Conflicts, if any, which may exist between the above items, will be resolved at the discretion of the Engineer.

C. Wherever the requirements of the Specifications or Drawings exceed those of the above items, the requirements of the Specifications or Drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.

D. Obtain all permits and pay all fees required by any governmental agency having jurisdiction over the work. Arrange all inspections required by these agencies. On completion of the work, furnish satisfactory evidence to the Engineer that the work is acceptable to the regulatory authorities having jurisdiction.

## 1.04 ELECTRICAL COORDINATION

A. Work Provided Under this Contract:
   1. Provide and install the complete electrical power distribution system shown on the drawings including equipment space and supporting raceway for future equipment.
   2. Provide and install all electrical equipment indicated on the drawings and described in the specifications including circuit breaker, panelboards, disconnects, local starters, wire, raceway, etc. complete in place.
   3. Provide and install new lightning protection and grounding systems complete in place.
   4. Provide all miscellaneous electrical including switches, terminations, fittings, wiring, conduit, junction boxes, etc. not specified but obviously necessary for a complete working system in place.
   5. After approval of the instrumentation submittal and most of the package systems, the electrical contractor shall arrange a meeting with the electrical engineer and verify that all power, control and instrumentation signals are present in a designated conduit.

B. Temporary Power:
   1. Provide temporary power for all office trailers and for all construction areas. Coordinate with local power and telephone utility for temporary construction power and telephone service during construction.

## 1.05 SUBMITTALS

A. Quality Control Submittals:
   1. Voltage Field Test Results.
   2. Voltage Balance Report.
   3. Equipment Line Current Report.
   4. Factory test certification and reports for all major electrical equipment.
   5. Site test certification and reports as specified in other Division 26, Electrical sections.
   6. As part of the electrical submittal, the contractor shall provide a minimum of 1/4”=1’-0” scaled layout of the electrical equipment in the electrical room or major electrical equipment in a mechanical room showing sizes of all equipment and their spatial relationship. Non-electrical equipment shall be approved before finalizing the electrical layout in mechanical rooms.

B. The following information shall be provided for all electrical equipment:
   1. A copy of each specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined shall signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation.
   2. Electrical equipment submittals shall be made by specification section. Submit one package per specification section and do not group multiple specification sections under one submittal package.
   3. Provide complete conduit and equipment layouts: a scaled plan layout of the electrical room(s) showing spatial relationships of all equipment as well as the overall size of the room. Minimum scale shall be 1/4”=1’-0”.
   4. Provide a conduit plan for major power, instrumentation and control conduits, both interior and exterior, showing routing, size and stub up locations for buried or in slab conduits.

## 1.06 ENVIRONMENTAL CONDITIONS

A. All chemical rooms and areas shall be designated as corrosive.

B. All indoor chemical and process equipment areas shall be considered wet locations.

C. Electrical equipment in rooms designated as Classified by NFPA 70 (national electrical code) as Division 1 or Division 2 shall meet all requirements set forth for that classification as described in NEC Article 500.

## 1.07 INSPECTION OF THE SITE AND EXISTING CONDITIONS

A. Verify all scaled dimensions prior to submitting bids.

B. Before submitting a bid, visit the site and determine conditions at the site and at all existing structures in order to become familiar with all existing conditions and electrical system which will, in any way or manner, affect the work required under this Contract. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to fulfill this requirement.

C. Carry out any work involving the shutdown of the existing services to any piece of equipment now functioning in existing areas at such time as to provide the least amount of inconvenience to the Owner. Do such work when directed by the Engineer.

D. After award of Contract, locate all existing underground utilities at each area of construction activity. Protect all existing underground utilities during construction. Pay for all required repairs without increase in Contract cost, should damage to underground utilities occur during construction.

## 1.08 RESPONSIBILITY

A. The Contractor shall be responsible for:
   1. Complete systems in accordance with the intent of these Contract Documents.
   2. Coordinating the details of facility equipment and construction for all Specification Divisions that affect the work covered under Division 26, Electrical.
   3. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.
   4. Coordinate with equipment supplier for dimensions of the equipment and ask the supplier to ship the equipment in section if the equipment is too large to enter the room (door) where the equipment will be installed. The cost to assembly the equipment at the job site shall be included in the bid price.

## 1.09 INTENT OF DRAWINGS

A. Electrical plan Drawings show only general location of equipment, devices, and raceway, unless specifically dimensioned. The Contractor shall be responsible for the proper routing of raceway, subject to the approval of the Engineer.

B. All electrical equipment sizes and characteristics have been based on manufacturer Eaton (Cutler-Hammer). If the Contractor chooses to and is allowed to substitute, the Contractor shall be responsible for fitting all the equipment in the available space as shown on the Drawings.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. Provide materials and equipment listed by UL wherever standards have been established by that agency.

B. Equipment Finish:
   1. Provide manufacturers' standard finish and color, except where specific color is indicated.
   2. If manufacturer has no standard color, provide equipment with ANSI No. 61, light gray color.

# PART 3 EXECUTION

## 3.01 GENERAL

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

B. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

## 3.02 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchboards, panel boards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

## 3.03 CHECKOUT AND START-UP

A. Voltage Field Test:
   1. Check voltage at point of termination of power company supply system to project when installation is essentially complete and is in operation.
   2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
   3. Record supply voltage (all three phases simultaneously on the same graph) for 24 hours during normal working day.
      a. Submit Voltage Field Test Report within 5 days of test.
   4. Unbalance Corrections:
      a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
      b. Obtain a written certification from a responsible power company official that the voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:
   1. Check line current in each phase for each piece of equipment.
   2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
   3. If any phase current for any piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

C. Start-Up:
   1. Demonstrate satisfactory operation of all 480-volt electrical equipment. Participate with other trades in all start-up activities.
   2. Assist the Instrumentation and Control (I&C) Contractor in verifying signal integrity of all control and instrumentation signals.

END OF SECTION

## SECTION 26_05_04

## BASIC ELECTRICAL MATERIALS AND METHODS

## 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):
      a. C55.1 - Standard for Shunt Power Capacitors.
      b. C62.11 - Standard for Metal-Oxide Surge Arrestors for AC Circuits.
      c. Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.
   2. American Society for Testing and Materials (ASTM):
      a. A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
      b. A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
      c. A570 - Standard Specification for Steel, Sheet, and Strip, Carbon, Hot-Rolled, Structural Quality.
   3. Federal Specifications (FS):
      a. W-C-596 - Connector, Receptacle, Electrical.
      b. W-S-896E - Switches, Toggle, Flush Mounted.
   4. National Electrical Contractor's Association, Inc. (NECA):
      a. 5055, Standard of Installation.
   5. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
      c. CP I - Shunt Capacitors.
      d. ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
      e. KS 1 - Enclosed Switches.
      f. LA I - Surge Arrestors.
      g. PB 1 - Panelboards.
      h. ST 20 - Dry-Type Transformers for General Applications.
      i. WD I - General Requirements for Wiring Devices.
   6. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC),
   7. Underwriters Laboratories, Inc. (UL):
      a. 67 - Standard for Panelboards.
      b. 98 - Standard for Enclosed and Dead-Front Switches.
      c. 198C - Standard for Safety High-Interrupting-Capacity Fuses, Current-Limiting Types.
      d. 198E - Standard for Class Q Fuses.
      e. F486E - Standard for Equipment Wiring Terminals.
      f. 489 - Standard for Molded Case Circuit Breakers and Circuit Breaker Enclosures.
      g. 508 - Standard for Industrial Control Equipment.
      h. 810 - Standard for Capacitors.

i. 943 - Standard for Ground-Fault Circuit Interrupters.
j. 1059 - Standard for Terminal Blocks.
k. 1561 - Standard for Dry-Type General-Purpose and Power Transformers.

## 1.02 SUBMITTALS

A. Shop Drawings:
1. Device boxes for use in hazardous areas.
2. Junction and pull boxes used at, or below, grade.
3. Hardware.
4. Terminal junction boxes.
5. Panelboards and circuit breaker data.
6. Fuses.
7. Contactors.
8. Transformers.
9. All other miscellaneous material part of this project.
10. Wire pulling compound.

B. Quality Control Submittals:
1. Test Report: Sound test certification for dry type power transformers (0 to 600-volt, primary).

## 1.03 QUALITY ASSURANCE

A. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

B. Hazardous Areas: Materials and devices shall be specifically approved for hazardous areas of the class, division, and group shown and of a construction that will ensure safe performance when properly used and maintained.

## 1.04 SPARE PARTS

A. Furnish, tag, and box for shipment and storage the following spare parts:
1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

# PART 2 PRODUCTS

## 2.01 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc- or cadmium-plated.

B. Cast Metal:
1. Box: Cast ferrous metal.
2. Cover: Gasketed, weatherproof, cast ferrous metal, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs (Cast Mounting) Manufacturer:
a. Crouse-Hinds; Type FS or FD.
b. Appleton; Type FS or FD.

C. Cast Aluminum:
   1. Material:
      a. Box: Cast, copper-free aluminum.
      b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
   2. Hubs: Threaded.
   3. Lugs: Cast mounting.
   4. Manufacturers:
      a. Crouse-Hinds; Type FS-SA or FD-SA.
      b. Appleton; Type FS or FD.

D. PVC-Coated Sheet Steel:
   1. Type: One-piece.
   2. Material: Zinc- or cadmium-plated.
   3. Coating: All surfaces; 40-mil PVC.
   4. Manufacturer: Appleton.

E. Nonmetallic:
   1. Box: PVC.
   2. Cover: PVC, weatherproof, with stainless steel screws.
   3. Manufacturer: Carlon; Type FS or FD, with Type E98 or E96 covers.

## 2.02 JUNCTION AND PULL BOXES

A. Outlet Boxes Used as Junction or Pull Box: As specified under Article 3.02 OUTLET AND DEVICE BOXES.

B. Large Sheet Steel Box: NEMA 250, Type 1.
   1. Box: Code-gauge, galvanized steel.
   2. Cover: Full access, screw type.
   3. Machine Screws: Corrosion-resistant.

C. Large Cast Metal Box: NEMA 250, Type 4.
   1. Box: Cast malleable iron, hot-dip galvanize finished, with drilled and tapped conduit entrances.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   4. Manufacturers, Surface Mounted Type:
      a. Crouse-Hinds; Series W.
      b. O-Z/Gedney; Series Y.
   5. Manufacturers, Recessed Type:
      a. Crouse-Hinds; Type WJBF.
      b. O-Z/Gedney; Series YR.

D. Large Stainless Steel Box: NEMA 250, Type 4X.
   1. Box: 14-gauge, ASTM A240, Type 304 stainless steel.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 304 stainless steel.
   4. Manufacturers:
      a. Hoffman Engineering Co.
      b. Robroy Industries.

E. Large Steel Box: NEMA 250, Type 4.
   1. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces, with final ANSI Z55.1, No. 61 gray enamel on exterior surfaces.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   4. Manufacturers:
      a. Hoffman Engineering Co.
      b. Robroy Industries.

F. Large Nonmetallic Box:
   1. NEMA 250, Type 4X.
   2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
   3. Cover: Hinged with screws.
   4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   5. Conduit hubs and mounting lugs.
   6. Manufacturers:
      a. Crouse-Hinds; Type NJB.
      b. Carlon; Series N, C, or H.
      c. Robroy Industries.

G. Concrete Box:
   1. Box: Reinforced, cast concrete.
   2. Cover: Cast iron.
   3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
   4. Manufacturers:
      a. Brooks Products Inc.; No. 36/36T.
      b. Qwikset; W 17.

## 2.03 WIRING DEVICES

A. Switches:
   1. NEMA WD I and FS W-S-896E.
   2. Specification grade, totally-enclosed, ACtype, 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:
      a. Office Areas: Ivory.
      b. Other Areas: Brown.
   6. Switches with Pilot Light: 125-volt, neon light with red jewel, or lighted toggle when switch is ON.
   7. Manufacturers:
      a. Bryant.
      b. Leviton.
      c. Hubbell.
      d. Pass and Seymour.
      e. Arrow Hart.

B. Receptacle, Single and Duplex:
   1. NEMA WD 1 and FS W-C-596.
   2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
   3. High strength, thermoplastic base color.
   4. Color:
      a. Office Areas: Ivory.
      b. Other Areas: 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. Manufacturers:
      a. Bryant.
      b. Leviton.
      c. Hubbell.
      d. Pass and Seymour.
      e. Sierra.
      f. Arrow Hart.

C. Receptacle, Ground Fault Circuit Interrupter: Duplex, specification grade, tripping at 5 mA.
   1. Color: Ivory.
   2. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, capable of interrupting 5,000 amps without damage.
   3. Size: For 2-inch by 4-inch outlet boxes.
   4. Standard Model: NEMA WD 1 with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   5. Feed-Through Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   6. Manufacturers:
      a. Pass and Seymour.
      b. Bryant.
      c. Leviton.
      d. Hubbell.
      e. Arrow Hart.

D. Receptacle, Special-Purpose:
   1. Rating and number of poles as indicated or required for anticipated purpose.
   2. Matching plug with cord-grip features for each special-purpose receptacle.

E. Multioutlet Surface Raceway System: Three-wire grounding receptacles, spaced on 6-inch centers with insulated grounding conductor to each receptacle.
   1. Color: Gray with black receptacles.
   2. Manufacturers:
      a. Plugmold; 2000.
      b. Walker; Duct 2GW.

## 2.04 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Plastic:
   1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
   2. Color: To match associated wiring device.
   3. Mounting Screw: Oval-head metal, color matched to plate.

C. Metal:
   1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
   2. Finish: ASTM A167, Type 302/304, satin.
   3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:
   1. Material: Malleable ferrous metal, with gaskets.
   2. Screw: Oval-head stainless steel.

E. Engraved:
   1. Character Height: 3/16 inch.
   2. Filler: Black.

F. Weatherproof:
   1. For Receptacles: Gasketed, cast metal or stainless steel, with individual cap over each receptacle opening.
   2. Mounting Screw: Stainless steel.
      a. Cap Spring: Stainless steel.
      b. Manufacturers:
         1) General Electric.
         2) Bryant.
         3) Hubbell.
         4) Sierra.
         5) Pass and Seymour.
         6) Crouse-Hinds; Type WLRD or WLRS.
         7) Bell.
         8) Arrow Hart.
   3. For Switches: Gasketed, cast metal incorporating external operator for internal switch.
      a. Mounting Screw: Stainless steel.
      b. Manufacturers:
      c. Crouse-Hinds; DS-181 or DS-185.
      d. Appleton; FSK-LVTS or FSK-IVS.

G. Raised Sheet Metal: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel boxes.

## 2.05 LIGHTING AND POWER DISTRIBUTION PANELBOARD (LP, IP, AND PP PANEL)

A. NEMA PB I, NFPA 70, and UL 67, including panelboards installed in motor control equipment.

B. Panelboards and Circuit Breakers: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

C. Short-Circuit Current Equipment Rating: Fully rated; series connected unacceptable.

D. Rating: If not otherwise shown in plans. Applicable to a system with available short-circuit current of 25,000 amperes rms symmetrical at 208Y/120 or 120/240 volts and 65,000 amperes rms symmetrical at 480Y/277 volts.

E. Where ground fault interrupter circuit breakers are indicated or required by code: 5-mA trip, 10,000 amps interrupting capacity circuit breakers.

F. Cabinet: As shown on plans.

G. Bus Bar:
   1. Material: Copper, full sized throughout length.
   2. Provide for mounting of future circuit breakers along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.
   3. Neutral: Insulated, rated 150 percent of phase bus bars with at least one terminal screw for each branch circuit.
   4. Ground: Copper, installed on panelboard frame, bonded to box with at least one terminal screw for each circuit.
   5. Lugs and Connection Points:
      a. Suitable for either copper or aluminum conductors.
      b. Solderless main lugs for main, neutral, and ground bus bars.
      c. Subfeed or through-feed lugs as shown.
   6. Bolt together and rigidly support bus bars and connection straps on molded insulators.

H. Circuit Breakers:
   1. NEMA AB 1 and UL 489.
   2. Thermal-magnetic, quick-make, quick-break, molded case, of the indicating type showing ON/OFF and TRIPPED positions of operating handle.
   3. Noninterchangeable, in accordance with NFPA 70.
   4. Locking: Provisions for handle padlocking, unless otherwise shown.
   5. Type: Bolt-on circuit breakers in all panelboards.
   6. Multipole circuit breakers designed to automatically open all poles when an overload occurs on one pole.
   7. Do not substitute single-pole circuit breakers with handle ties for multipole breakers.
   8. Do not use tandem or dual circuit breakers in normal single-pole spaces.
   9. Ground Fault Interrupter:
      a. Equip with conventional thermal-magnetic trip and ground fault sensor rated to trip in 0.025 second for a 5-milliampere ground fault (UL 943, Class A sensitivity).
      b. Sensor with same rating as circuit breaker and a push-to-test button.

I. Manufacturers:
   1. Schneider Electric.
   2. Eaton Electrical.
   3. Approved equal.

## 2.06 MINI-POWER CENTER (MPC)

A. General: Transformer, primary and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 4X enclosure. Complete MPC shall be rated for 22,000 amperes RMS symmetrical.

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: See plans.
   5. Secondary Voltage: See plans.

C. Panelboard: Full, UL 489, short-circuit current rated.
   1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
   2. Number and Breaker Ampere Ratings: Refer to Panel Schedule.

## 2.07 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA AB I, UL 489 listed for use at location of installation.

B. Minimum Interrupt Rating: As shown or as required.

C. Thermal-magnetic, quick-make, quick-break, indicating type, showing ON/OFF and TRIPPED indicating positions of the operating handle.

D. Suitable for use with 75 degrees Celsius wire at full NFPA 70, 75 degrees Celsius ampacity.

E. Locking: Provisions for padlocking handle.

F. Multipole breakers to automatically open all poles when an overload occurs on one-pole.

G. Enclosure: NEMA 250, Type 12, Industrial Use, 4X - outdoors, wet locations and corrosive areas, unless otherwise shown.

H. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position.

I. Do not provide single-pole circuit breakers with handle ties where multipole circuit breakers are shown.

## 2.08 FUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. UL 98 listed for use and location of installation.

B. NEMA KS 1 and UL 98 Listed for application to system with available short circuit current of 22,000 amps rms symmetrical.

C. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

D. Suitable for use with 75 degrees Celsius wire at full NFPA 70, 75 degrees Celsius ampacity.

E. Fuse mountings shall reject Class H fuses and accept only current-limiting fuses specified.

F. Enclosure: NEMA 250, Type 12, Industrial Use, 4X - outdoors, wet locations and corrosive areas, unless otherwise shown.

G. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

## 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 Celsius wire at full NFPA 70, 75 degrees Celsius ampacity.

D. Enclosure: NEMA 250, Type 12, industrial use, 4X outdoors, wet locations and corrosive areas, unless otherwise shown.

E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

## 2.10 FUSE, 0 TO 600 VOLTS

A. Current-limiting, with 200,000 ampere rms interrupting rating.

B. Provide to fit mountings specified with switches and features to reject Class H fuses.

C. Motor and Transformer Circuits, 0- to 600-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-1, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPS-RK.
      b. Littlefuse; Type LLS-RK.

D. Motor and Transformer Circuits, 0- to 250-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-1, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPN-RK.
      b. Littlefuse; Type LLN-RK.

E. Feeder and Service Circuits, 0- to 600-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-I, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPS-RK.
      b. Littlefuse; Type LLS-RK.

F. Feeder and Service Circuits, O- to 250-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-I, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPN-RK.
      b. Littlefuse; Type LLN-RK.

G. Feeder and Service Circuits, 0- to 600-Volt:
   1. Amperage: 601 to 6,000.
   2. UL 198C, Class L, double O-rings and silver links.
   3. Manufacturers:
      a. Bussmann; Type KRP-C.
      b. Littlefuse; Type KLPC.

## 2.11 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCHES

A. Contact Rating: NEMA ICS 2, Type A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Lights: Push-to-test.

D. Pushbutton Color:
   1. ON or START: Black.
   2. OFF or STOP: Red.

E. Pushbuttons and selector switches lockable in the OFF position where indicated.

F. Legend Plate:
   1. Material: Aluminum.
   2. Engraving: 11 character/spaces on one line, 14 character/spaces on each of two lines, as required, indicating specific function.
   3. Letter Height: 7/64 inch.

G. Manufacturers:
   1. Heavy-Duty, Oiltight Type:
      a. General Electric; Type CR 104P.
      b. Square D; Type T.
      c. Cutler-Hammer; Type 10250T.
   2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
      a. Square D; Type SK.
      b. General Electric; Type CR 104P.
      c. Cutler-Hammer; Type E34.
      d. Crouse-Hinds; Type NCS.

## 2.12 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Terminal Blocks: Provide separate connection point for each conductor entering or leaving box.
   1. Spare Terminal Points: 25 percent.

C. Interior Finish: Paint with white enamel or lacquer.

## 2.13 TERMINAL BLOCK (0 TO 600 VOLTS)

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of all control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between the compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:
   1. Capable of wire connections without special preparation other than stripping.
   2. Capable of jumper installation with no loss of terminal or rail space.
   3. Individual, rail mounted.

I. Marking system allowing use of preprinted or field-marked tags.

J. Manufacturers:
   1. Weidmuller.
   2. Ideal.
   3. Electrovert.

## 2.14 MAGNETIC CONTROL RELAY

A. NEMA ICS 2, Class A600 (600 volts, 10 amps continuous, 7,200VA make, 720VA break), industrial control with field convertible contacts.

B. Time Delay Relay Attachment:
   1. Pneumatic type, timer adjustable from 0.2 to 60 seconds (minimum).
   2. Field convertible from ON delay to OFF delay and vice versa.

C. Latching Attachment: Mechanical latch having unlatching coil and coil clearing contacts.

D. Manufacturers:
   1. Cutler-Hammer; Type M-600.
   2. General Electric; Type CR120B.

## 2.15 RESET TIMER

A. Drive: Synchronous motor, solenoid operated clutch.

B. Mounting: Semiflush, panel.

C. Contacts: 10-amp, 120-volt.

D. Manufacturers:
   1. Eagle Signal; Bulletin 125.
   2. Automatic Timing and Controls; Bulletin 305.

## 2.16 ELAPSED TIME METER

A. Drive: Synchronous motor.

B. Range: 0 to 99,999.9 hours, nonreset type.

C. Mounting: Semiflush, panel.

D. Manufacturers:
   1. General Electric; Type 240, 2-1/2-inch Big Look.
   2. Eagle Signal; Bulletin 705.

## 2.17 MAGNETIC CONTACTOR

A. NEMA ICS 2, UL 508.

B. Electrically operated, electrically held.

C. Main Contacts:
   1. Power driven in one direction with gravity dropout.
   2. Silver alloy with wiping action and arc quenchers.
   3. Continuous-duty, rated 30 amperes, 600-volt.
   4. Three-pole.

D. Control: Two-wire.

E. One normally open and one normally closed auxiliary contacts rated 10 amperes at 480-volt.

F. Enclosure: NEMA 250, Type 12, unless otherwise shown.

G. Manufacturers:
   1. Schneider Electric.

2. Eaton Electrical.
3. Approved equal.

## 2.18 MAGNETIC LIGHTING CONTACTOR

A. NEMA ICS 2, UL 508.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and electrically held in both OPEN and CLOSED position.

D. Main Contacts:
1. Power driven in both directions.
2. Double-break, continuous-duty, rated 20 amperes, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts.
3. Marked for electric discharge lamps, tungsten, and general-purpose loads.
4. Position not dependent on gravity, hooks, latches, or semi-permanent magnets.
5. Capable of operating in any position.
6. Visual indication for each contact.

E. Auxiliary contact relay for three-wire control.

F. One normally open and one normally closed auxiliary contacts rated 10 amperes at 480-volt.

G. Fully rated neutral plate.

H. Provision for remote pilot lamp with use of auxiliary contacts.

I. Clamp type, self-rising terminal plates for solderless connections.

J. Enclosure: NEMA 250, Type 12, Dust-Tight, Drip-Tight, Industrial Use, unless otherwise shown.

K. Manufacturers:
1. Schneider Electric.
2. Eaton Electrical.
3. Square D.

## 2.19 INDUSTRIAL CAPACITORS

A. UL 810, NEMA CP1, ANSI C55.1, and NFPA 70, Article 460.

B. Enclosed, outdoor, weatherproof, three-phase capacitor units containing internally mounted, indicating type, high interrupting-capacity, current limiting fuses and discharge resistors.

C. Units containing PCB dielectric fluid are unacceptable.

D. Kilovar Ratings:
   1. Kilovar ratings of capacitors connected to individual motor circuits were selected based on expected motor power factor.
   2. Check motor nameplate and manufacturer's power factor and no-load current data for actual motor installed.
   3. Reduce capacitor kVAR if required, so the size does not exceed the motor manufacturer's recommended maximum size, and so it does not exceed the value required to raise motor no-load power factor to 0.95.
   4. Manufacturers:
      a. ABB.
      b. Square D.

## 2.20 THERMOSTAT

A. Rating: 7.4 amps continuous, 44 amps locked rotor current at 120 volts and 3.7 amps continuous, 22 amps locked rotor current at 240 volts.

B. Line voltage, single-stage, treated to resist corrosion, dust, dirt, and humidity with sealed SPDT contacts.

C. Heating Adjustment Range: 35 to 100 degrees Fahrenheit.

D. Cooling or Ventilating Adjustment Range: 70 to 140 degrees Fahrenheit.

E. Manufacturer: Honeywell; Type T631F1084.

## 2.21 DRY TYPE TRANSFORMER (0- TO 600-VOLT PRIMARY)

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Self-cooled, two-winding, UL K-4 rated for nonlinear loads.

C. Insulation Class and Temperature Rise: Manufacturer's standard.

D. Core and Coil:
   1. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA.
   2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

E. Enclosure:
   1. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated.
   2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
   3. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, nonventilated.
   4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
   5. Outdoor Transformers: NEMA 250, Type 3R.

F. Wall Bracket: For single-phase units, 15 to 37-1/2 kVA, and for three-phase units, 15 to 30 kVA.

G. Voltage Taps:
   1. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
   2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
   3. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
   4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

H. Impedance: 4.5 percent minimum on units 75 kVA and larger.

I. Maximum Sound Level: NEMA ST 20:
   1. 40 decibels for 0 to 9 kVA.
   2. 45 decibels for 10 to 50 kVA.
   3. 50 decibels for 51 to 150 kVA.
   4. 55 decibels for 151 to 300 kVA.
   5. 60 decibels for 301 to 500 kVA.

J. Vibration Isolators:
   1. Rated for transformer's weight.
   2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
   3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
   4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

K. Manufacturers:
   1. Eaton Electrical.
   2. Square D.
   3. Or approved equal.

## 2.22 LOW VOLTAGE, SECONDARY SURGE PROTECTIVE EQUIPMENT

A. NEMA LA1, ANSI C62. 11.

B. Surge Capacitor:
   1. Impregnated with non-PCB, biodegradable dielectric fluid.
   2. Integral discharge resistor which will drain residual voltage to 50 volts crest in less than I minute after disconnection from circuit.

C. Arrestor: High strength metal oxide valve elements enclosed in high strength, corrosion resistant, molded resin housing.

D. Equip capacitor and arrestor with mounting nipple, flat washer, and nut suitable for knockout or bracket mounting.

## 2.23 SUPPORT AND FRAMING CHANNELS

A. Material:
   1. Dry indoors - galvanized.
   2. All Other Areas: ASTM A167, Type 316 stainless steel or fiber-reinforced epoxy, as required.

B. Finish:
   1. Dry indoors: Galvanized.
   2. All Other Areas: ASTM A167, Type 316 stainless steel or fiber-reinforced epoxy, as required.

C. Inserts: Continuous.

D. Beam Clamps: Gray cast iron.

E. Manufacturers:
   1. B-Line.
   2. Unistrut.

## 2.24 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: White, engraved to a black core.

D. Engraving:
   1. Pushbuttons/Selector Switches: Name of drive controlled on one, two, or three lines, as required.
   2. Panelboards: Panelboard designation, service voltage, and phases.

E. Letter Height:
   1. Pushbuttons/Selector Switches: 1/8 inch.
   2. Panelboards: 1/4 inch.

## 2.25 SURGE PROTECTIVE DEVICES

A. This section describes the material and installation requirements surge protective devices (SPD) in switchboards, panelboards, and motor control centers for the protection of all AC electrical circuits.

B. SPD shall be listed and component recognized in accordance with UL 1449 and UL 1283.

C. SPD shall be installed and warranted by and shipped from the electrical distribution equipment manufacturer’s factory.

D. SPD shall provide surge current diversion paths for all modes of protection; L-L, L-N, L-G, N-G in WYE systems, and L-L, L-G in DELTA systems.

E. SPD shall be modular in design. Each module shall be fused with a surge rated fuse.

F. A UL approved disconnect switch shall be provided as a means of disconnect in the switchboard device only.

G. SPD shall meet or exceed the following criteria:
   1. Maximum surge current capability (single pulse rated) shall be:
      a. Service entrance switchboard 300kA.
      b. Branch panelboards 150kA.
      c. Motor control centers 80kA.
   2. UL 1449 Listed and Recognized Component Suppression Voltage Ratings shall not exceed the following:

| Voltage | L-N | L-G | N-G |
|---|---|---|---|
| 208Y/120 | 400V | 400V | 400V |
| 480Y/277 | 800V | 800V | 800V |

H. SPD shall have a minimum EMI/RFI filtering of -44dB at 100kHz with an insertion ration of 50:1 using MIL STD. 220A methodology.

I. SPD shall be provided with 1 set of NO/NC dry contacts.

J. SPD shall have a warranty for a period of five years, incorporating unlimited replacements of suppressor parts if they are destroyed by transients during the warranty period. Warranty will be the responsibility of the electrical distribution equipment manufacturer.

K. Approve manufactures are:
   1. Eaton Electrical
   2. Square D.
   3. Approved equal.

## 2.26 CORRUGATED SWITCHBOARD NON-CONDUCTIVE MATS

A. Specification:
   1. Usage - Around electronic and high-voltage apparatus.
   2. Compound - 1/4-inch Vinyl.
   3. ANSI/ASTM Rating - D178-01 - Type II - Class 2.
   4. Dielectric Breakdown - ASTM Dl49-97a (Minimum 30,000 V): PASS.
   5. Coefficient of Friction - 0.91 Dry per ASTM F1677.
   6. Tabor Abrasion - 1 percent lost at 1,000 cycles per Fed. Std. 191.
   7. Flammability - "A" Rating per MVSS 302.
   8. Flame Resistance - ASTM D178-01: 0.224 mm/s.
   9. Accelerated Aging - ASTM D573-88: 1000 psi.
   10. Electric Proof Test - ASTM D178-01 (Minimum 20,000 V - 1 min): PASS.
   11. Elongation - ASTM D412-98a Die C: 300 percent.
   12. Moisture Absorption - ASTM D570-95: 0.2 percent.
   13. 03 Resistance Test: Method B - ASTM D178-01: PASS.
   14. Oil Resistance - ASTM D471-97: 2.0 percent.
   15. Tensile Strength - ASTM D412-98a Die C: 1212 psi.

16. Tension Set - ASTM D412-98a Die B: 0.228 in.

## PART 3 EXECUTION

### 3.01 GENERAL

A. Install equipment in accordance with NECA 5055.

### 3.02 INSULATION MATS INSTALLATION

A. Provide and install corrugated insulation mats in front of all electrical equipment (transformers, switchgears, MCCs, panelboards, etc.) to protect personnel from electrocution.

### 3.03 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in the 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. Ceiling Outlet: Minimum 4-inch octagonal sheet steel device box, unless otherwise required for installed fixture.
   3. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.

C. Locations:
   1. Drawing locations are approximate.
   2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by engineer.
   3. Light Switch: Install on lock side of doors.
   4. Light Fixture: Install in symmetrical pattern according to room layout unless otherwise shown.

D. Mounting Height:
   1. General:
      a. Measured to centerline of box.
      b. Where specified heights do not suit building construction or finish, mount as directed by Engineer.
   2. Light Switch: 48 inches above floor.
   3. Thermostat: 54 inches above floor.
   4. Telephone Outlet: 6 inches above counter tops or 15 inches above floor.
   5. Wall Mounted Telephone Outlet: 52 inches above floor.
   6. Convenience Receptacle:
      a. General Interior Areas: 15 inches above floor.
      b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of splashback, or 6 inches above countertops without splashback.

c. Industrial Areas, Workshops: 48 inches above floor.
d. Outdoor, All Areas: 24 inches above finished grade.

7. Special-Purpose Receptacle: 54 inches above floor or as shown.

E. Install plumb and level.

F. Flush Mounted:
1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

G. Support boxes independently of conduit by attachment to building structure or structural member.

H. Install bar hangers in frame construction, or fasten boxes directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws threaded into steelwork.

I. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

J. Provide plaster rings where necessary.

K. Boxes embedded in concrete or masonry need not be additionally supported.

L. Install stainless steel mounting hardware in industrial areas.

M. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

N. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.

O. Box Type (Steel Raceway System):
1. Exterior Locations:
a. Exposed Raceways: Cast metal.
b. Concealed Raceways: Cast metal.
c. Concrete Encased Raceways: Cast metal.
d. Class I, II, or III Hazardous Areas: Cast metal.
2. Interior Dry Locations:
a. Exposed Rigid Conduit: Cast metal.
b. Exposed EMT: Sheet steel.
c. Concealed Raceways: Sheet steel.
d. Concrete Encased Raceways: Cast metal.
e. Lighting Circuits, Ceiling: Sheet steel.
f. Class I, II, or III Hazardous Areas: Cast metal.
3. Interior Wet Locations:
a. Exposed Raceways: Cast metal.
b. Concealed Raceways: Cast metal.
c. Concrete Encased Raceways: Cast metal.

d. Lighting Circuits, Ceiling: Sheet steel.
e. Class I, II, or III Hazardous Areas: Cast metal.

4. Cast-in-Place Concrete Slabs: Sheet steel.

P. Box Type (Rigid Aluminum Raceway System): Cast aluminum.

Q. Box Type (Nonmetallic Raceway System):
1. Corrosive Locations: Nonmetallic.
2. Exposed Raceways: Nonmetallic.
3. Concealed Raceways: Nonmetallic.
4. Concrete Encased Raceways: Nonmetallic.

R. Box Type, Corrosive Locations (PVC-Coated Rigid Galvanized Steel Raceway System): PVC coated cast metal.

## 3.04 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.

E. Installed boxes shall be accessible.

F. Do not install on finished surfaces.

G. Install plumb and level.

H. Support boxes independently of conduit by attachment to building structure or structural member.

I. Install bar hangers in frame construction, or fasten boxes directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded threaded studs on steelwork.

J. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

K. Boxes embedded in concrete or masonry need not be additionally supported.

L. At or Below Grade:
1. Install boxes for below grade conduits 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.

M. Flush Mounted:
1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

N. Mounting Hardware:
1. Noncorrosive Interior Areas: Galvanized.
2. All Other Areas: Stainless steel.

O. Location/Type:
1. Finished, Indoor, Dry: NEMA 250, Type 1.
2. Unfinished, Indoor, Dry: NEMA 250, Type 12.
3. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.
4. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.
5. Unfinished, Indoor and Outdoor, Hazardous: NEMA 250, Type 7 and Type 9, where indicated.
6. Underground Conduit: Concrete Encased.
7. Corrosive Locations: Nonmetallic.

## 3.05 TELEPHONE TERMINAL CABINET (TTC)

A. Not applicable.

## 3.06 TELEPHONE OUTLET

A. Not applicable.

## 3.07 WIRING DEVICES

A. Switches:
1. Mounting Height: See Article 3.02 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 up.
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.

C. Multioutlet Surface Raceway System:
   1. Install in accordance with manufacturer's instructions.
   2. Wire alternate outlets to each circuit where two-circuit, three-wire supply is shown.

## 3.08 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to the 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.

E. Engrave with designated titles.

F. Types (Unless Otherwise Shown):
   1. Office: Stainless Steel.
   2. Exterior: Weatherproof.
   3. Interior:
      a. Flush Mounted Boxes: Stainless Steel.
      b. Surface Mounted, Cast Metal Boxes: Cast metal.
      c. Surface Mounted, Sheet Steel Boxes: Stainless Steel.
      d. Surface Mounted, Nonmetallic Boxes: Plastic.

## 3.09 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Heavy-Duty, Oiltight Type: Locations (Unless Otherwise Shown): Nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   1. Locations (Unless Otherwise Shown): Nonhazardous, outdoor, or normally wet areas.
   2. Mounting: NEMA 250, Type 4X enclosure.

## 3.10 TERMINAL JUNCTION BOX

A. Install in accordance with Article 3.03 JUNCTION AND PULL BOXES.

B. Label each block and terminal with permanently attached, nondestructible tag.

C. Do not install on finished outdoor surfaces.

D. Location:
   1. Finished, Indoor, Dry: NEMA 250, Type 1.
   2. Unfinished, Indoor, Dry: NEMA 250, Type 12.

3. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.
4. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.

## 3.11 LIGHTING AND POWER DISTRIBUTION PANELBOARD

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.

## 3.12 INDUSTRIAL CAPACITORS

A. Provide suitable hangers or mounting brackets for wall or ceiling mounting.

## 3.13 DRY TYPE TRANSFORMER (0- TO 600-VOLT PRIMARY)

A. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

B. Provide moistureproof, flexible conduit for electrical connections.

C. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

D. Provide wall brackets for single-phase units, 15 to 167-1/2 kVA, and three-phase units, 15 to 112 kVA.

## 3.14 SUPPORT AND FRAMING CHANNEL

A. Furnish zinc-rich primer; paint cut ends prior to installation, where applicable.

B. Install where required for mounting and supporting electrical equipment and raceway systems.

## 3.15 MOTOR SURGE PROTECTION

A. Ground in accordance with NFPA 70.

B. Low Voltage: Ground terminals to equipment bus.

END OF SECTION

## SECTION 26_05_05

## CONDUCTORS

## 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):
      a. 386 - Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   2. American Society for Testing and Materials (ASTM):
      a. A167 - Standard Specification for Stainless and Heat Resisting Chromium-Nickel-Plated Steel Plate, Sheet, and Strip.
      b. B3 - Standard Specification for Soft or Annealed Copper Wire.
      c. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
      d. B263 - Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.
   3. Association of Edison Illuminating Companies (AEIC):
      a. CS 5 - Crosslinked Polyethylene Insulated Shielded Power Cables Rated 5 Through 35 kV.
      b. CS 6 - Ethylene- Propylene-Rubber-Insulated Shielded Power Cables Rated 5 Through 69 kV.
   4. Insulated Cable Engineer's Association, Inc. (ICEA):
      a. T-29-250 - Procedure for Conducting Vertical Cable Tray Flame Test With a Theoretical Heat Input of 210,000 Btu/hour.
   5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 48 - Standard Test Procedures and Requirements or High-Voltage Alternating Current Cable Terminations.
      b. 404 - Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5,000V through 46,000V and Cable Joints for Use with Laminated Dielectric Cable Rated 2,500V through 500,000V.
   6. National Electrical Contractors Association, Inc. (NECA):
      a. 5055 - Standard of Installation.
   7. National Electrical Manufacturers' Association (NEMA):
      a. CC 1 - Electric Power Connectors for Substations.
      b. WC 3 - Rubber-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      c. WC 5 - Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      d. WC 7 - Crosslinked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      e. WC 8 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      f. WC 55 - Instrumentation Cables and Thermocouple Wire.
   8. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).

9. Underwriters Laboratories, Inc. (UL):
    a. 13 - Standard for Safety Power-Limited Circuit Cables.
    b. 44 - Standard for Safety Rubber-Insulated Wires and Cables.
    c. 62 - Standard for Safety Flexible Cord and Fixture Wire.
    d. 486A - Standard for Safety Wire Connector and Soldering Lugs for Use with Copper Conductors.
    e. 486B - Standard for Safety Wire Connectors and Soldering Lugs for Use with Aluminum Conductors.
    f. 510 - Standard for Safety Insulating Tape.
    g. 854 - Standard for Safety Service-Entrance Cables.
    h. 910 - Standard for Safety Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air Handling Spaces.
    i. 1072 - Standard for Safety Medium-Voltage Power Cables.
    j. 1277 - Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
    k. 1581 - Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

## 1.02 SUBMITTALS

A. Shop Drawings:
    1. Wire and cable descriptive product information.
    2. Wire and cable accessories descriptive product information.
    3. Cable fault detection system descriptive product information.
    4. Manufactured wiring systems descriptive product information.
    5. Manufactured wire systems rating information.
    6. Manufactured wire systems dimensional drawings.
    7. Manufactured wire systems special fittings.
    8. Busway descriptive product information.
    9. Busway rating information.
    10. Busway dimensional drawings.
    11. Busway special fitting information.
    12. Busway-equipment interface information for equipment to be connected to busways.

B. Quality Control Submittals:
    1. Certified Factory Test Report for conductors 600 volts and below.
    2. Certified Factory Test Report per AEIC CS6, including AEIC qualification report for conductors above 600 volts.

## 1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

# PART 2 PRODUCTS

## 2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 3, WC 5, and WC 7.

B. Conductor Type:
   1. 120- and 277-Volt Lighting, No. 10 AWG and Smaller: Stranded copper.
   2. 120-Volt Receptacle Circuits, No. 10 AWG and Smaller: Stranded copper.
   3. All Other Circuits: Stranded copper.

C. Insulation: Type THHN/THWN, except for sizes No. 6 and larger, with XHHW insulation.

D. Direct Burial and Aerial Conductors and Cables:
   1. Type USE/RHH/RHW insulation, UL t (54 listed, Type RHW-2/USE-2.
   2. Conform to physical and minimum thickness requirements of NEMA WC 3.

E. Flexible Cords and Cables:
   1. Type SOW-A50 with ethylene propylene rubber insulation in accordance with UL 62.
   2. Conform to physical and minimum thickness requirements of NEMA WC 8.

F. Cable Tray Conductors and Cables: Type TC.

## 2.02 600-VOLT RATED CABLE

A. General:
   1. Type: TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu/hr, and NFPA 70, Article 340, or UL 13 Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725.
   2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
   3. Suitable for installation in open air, in cable trays, or conduit.
   4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
   5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Wire and Connectors:
   1. Cable shall be rated for 600 volts and shall meet the requirements below:
   2. Conductors shall be stranded.
   3. All wire shall be brought to the job in unbroken packages and shall bear the data of manufacturing; not older than 12 months.
   4. Type of wire shall be XHHW or THHN, rated 75 degrees C suitable for wet locations except where required otherwise by the drawings.
   5. No wire smaller than No. 12 gauge shall be used unless specifically indicated.
   6. Conductor metal shall be copper.
   7. All conductors shall be megger tested after installation and insulation must be in compliance with the Insulated Power Cable Engineers Association Minimum Values of Insulation Resistance.

C. Type I-Multiconductor Control Cable:
   1. Conductors:
      a. No. 14 AWG, seven-strand copper.
      b. Insulation: 15-mil PVC with 4-mil nylon.
      c. UL 1581 listed as Type THHN/THWN rated VW-I.
      d. Conductor group bound with spiral wrap of barrier tape.

e. Color Code: In accordance with NEMA WC 5, Method 1, Sequence K-2.

2. Cable: Passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
3. Cable Sizes:

| Number of Conductors | Maximum Outside Diameter (inches) | Jacket Thickness (mils) |
|---|---|---|
| 3 | 0.41 | 45 |
| 5 | 0.48 | 45 |
| 7 | 0.52 | 45 |
| 12 | 0.72 | 60 |
| 19 | 00.83 | 60 |
| 25 | 1.00 | 60 |
| 37 | 1.15 | 80 |

4. Manufacturers:
   a. Okonite Co.
   b. Rome Cable.

D. Type 2-Multiconductor Power Cable:
   1. Conductors:
      a. Class B stranded, coated copper.
      b. Insulation: Chemically crosslinked ethylene-propylene with Hypalon jacket.
      c. UL 1581 listed as Type EPR, rated VW-1.
      d. Color Code: Conductors, size No. 8 AWG and smaller, colored conductors, NEMA WC5 Method 1, color 5 per Article 3.02 POWER CONDUCTOR COLOR CODING. Conductors, size No. 6 AWG and larger, NEMA WC5, Method 4.
   2. Cable pass the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
   3. Cable Sizes:

| Conductor Size | Minimum Ground Wire Size | Number of Conductors | Maximum Outside Diameter (Inches) | Nominal Jacket Thickness (Mils) |
|---|---|---|---|---|
| 12 | 12 | 2<br>3<br>4 | 0.42<br>0.45<br>0.49 | 45<br>45<br>45 |
| 10 | 10 | 2<br>3<br>4 | 0.54<br>0.58<br>0.63 | 60<br>60<br>60 |
| 8 | 10 | 3<br>4 | 0.66<br>0.72 | 60 |
| 6 | 8 | 3<br>4 | 0.74<br>0.81 | 60 |
| 4 | 6 | 3<br>4 | 0.88<br>0.97 | 60<br>80 |
| 2 | 6 | 3<br>4 | 1.01<br>1.11 | 80 |
| 1/0 | 6 | 3<br>4 | 1.22<br>1.35 | 80 |

| Conductor Size | Minimum Ground Wire Size | Number of Conductors | Maximum Outside Diameter (Inches) | Nominal Jacket Thickness (Mils) |
|---|---|---|---|---|
| 2/0 | 4 | 3<br>4 | 1.32<br>1.46 | 80 |
| 4/0 | 4 | 3<br>4 | 1.56<br>1.78 | 80 |

4. Manufacturers:
   a. Okonite Co.
   b. Pome Cable.

E. Type B-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.
   1. Outer Jacket: 45-mil nominal thickness.
   2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
   3. Dimension: 0.31-inch nominal OD.
   4. Conductors:
      a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
      b. 20 AWG, seven-strand tinned copper drain wire.
      c. Insulation: 15-mil nominal PVC.
      d. Jacket: 4-mil nominal nylon.
      e. Color Code: Pair conductors black and red.
   5. Manufacturers:
      a. Okonite Co.
      b. Alpha Wire Corp.
   6. The following test shall be performed on instrumentation and control system cables. All tests shall be end-to-end test of installed cables with the ends supported in free air, not adjacent to any ground object. All test data shall be recorded on forms acceptable to the Engineer. Complete records of all tests shall be made and delivered to the Engineer.
      a. Continuity tests shall be performed by measuring wire/shield loop resistances of signal cable as the wires, taken one at a time, are shorted to the channel shield. No loop resistance measurement shall carry by more than $\pm$2 ohms from the calculated average loop resistance valve.
      b. Insulation resistance tests shall be performed by using a 500 volt megohmeter to measure the insulation resistance between each channel wire and channel shield, between individual channel shields in a multi-channel cable, between each individual channel and the overall cable shield in multi-channel cable, between each wire and ground, and between each shield and ground. Values of resistance less than 10 megohms shall be unacceptable.

F. Type B1-No. 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   1. Outer Jacket: 45-mil nominal.
   2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.

3. Dimension: 0.32-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand, tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nylon.
    e. Color Code: Triad conductors black, red, and white.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.

G. Type B2-No. 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 55 requirements.
1. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8
    b. Tinned copper drain wires.
    c. Pair drain wire size AWG 20, group drain wire size AWG 18.
    d. Insulation: 15-mil PVC.
    e. Jacket: 4-mil nylon.
    f. Color Code: Pair conductors black and red with red conductor numerically printed for group identification.
    g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

| Number of Pairs | Maximum Outside Diameter (inches) | Nominal Jacket Thickness (mils) |
|---|---|---|
| 4 | 0.50 | 45 |
| 8 | 0.68 | 60 |
| 12 | 0.82 | 60 |
| 16 | 0.95 | 80 |
| 24 | 1.16 | 80 |
| 36 | 1.33 | 80 |
| 50 | 1.56 | 80 |

4. Manufacturers:
    a. Okonite Co.

H. Alpha Wire Corp.Type B3-No. 18 AWG, Multi-twisted Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55.
1. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
    b. Tinned copper drain wire size 18 AWG.

c. Insulation: 15-mil nominal PVC.
d. Jacket: 4-mil nylon.
e. Color Code: Pair conductors black and red, with red conductor numerically printed for group identification.

2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

| Number of Pairs | Maximum Outside Diameter (inches) | Nominal Jacket Thickness (mils) |
|---|---|---|
| 4 | 0.46 | 45 |
| 8 | 0.63 | 60 |
| 12 | 0.75 | 60 |
| 16 | 0.83 | 60 |
| 24 | 1.06 | 80 |
| 36 | 1.21 | 80 |
| 50 | 1.42 | 80 |

4. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.

I. Variable Frequency Drive (VFD) Output Power Cable:

J. Variable Frequency Drive (VFD) Output Power Cable:
1. Section applies to power cables routed between the output of VFD's and motor terminals indicated as VFD rated conductors.
2. Cable shall be rated for 600 volts type MC and shall meet the requirements below:
   a. Conductors shall be stranded copper.
   b. All wire shall be brought to the job in unbroken packages and shall bear the data of manufacturing; not older than 12 months.
   c. Type of wire shall be XHHW or RHW rated 75 degrees C suitable for wet locations, or XHHW-2 or RHW-2 rated at 90 degrees C suitable for wet locations.
   d. No wire smaller than No. 12 gauge shall be used unless specifically indicated.
   e. Cable construction shall consist of three insulated current-carrying phase conductors and three bare ground conductors, symmetrically placed between the phase conductors, and twisted beneath a continuous outer shield and overall polymeric jacket.
   f. Outer shield must be continuous corrugated or helical tape bare aluminum or bare copper or continuous corrugated welded armor.

3. Each ground conductor size (circular mil area) shall be one-third (1/3) of the NEC required size (circular mil area) for a single ground conductor. If one third of the required circular mil area does not correspond to a standard size (circular mil area) of construction, the next largest size of standard construction shall be us All conductors shall be megger tested after installation and insulation must be in compliance with the Insulated Power Cable Engineers Association Minimum Values of Insulation Resistance.
4. Manufacturers:
    a. Southwire.
    b. General Cable.
    c. Belden.
    d. Approved Equal.

K. Ethernet Cat. 6e UTP Cable (Copper):
1. Section applies to all Ethernet Cable (Copper) except for Fiber Optic cable.
2. Conductor Physical Characteristics: 4 twisted pairs (8 conductors), 23 AWG solid bare Copper with Polyolefin Insulation. Overall Nominal Diameter: 0.235 inch. Operating Temperature Range: -20 degrees C to +75 degrees C. Model Number – 7881A, Belden Inc.
3. NEC/UL specification CMR, UL444, UL verified category 6.
4. Manufacturer: Belden Inc.

## 2.03 FIBER OPTIC CABLE AND ACCESSORIES

A. Fiber Optic Cable:
1. Fiber Characteristics: Single-Mode.
    a. Comply with TIA/EIA 568.
    b. 8.3/125 μm glass single-mode.
    c. Tight-buffered, 900 μm buffer:
        1) Inner buffer: Acrylate, UV-cured, soft.
        2) Outer buffer: PVC, elastomeric, hard.
    d. Maximum Attenuation: Inside Plant 1,310/1,550 nm: 1 dB/km.
    Outside Plant 1,310/1,550 nm: 0.35/0.2 dB/km.
    e. Color-coded buffer.
    f. Minimum Bend Radius, Buffered Fiber: 1 inch.
    g. Proof Testing: 100 kpsi.
    h. Riser or plenum rated cable shall be used for all interior installations.
2. Fiber Characteristics: Multimode OM3:
    a. Comply with TIA/EIA 598.
    b. 50/125 μm graded-index corning glass.
    c. Tight-Buffered, 900 μm buffer:
        1) Inner buffer: Acrylate, UV-cured, soft.
        2) Outer buffer: PVC, elastomeric, hard.
    d. Maximum Attenuation:
        1) 850 nm: 2.3 dB/km.
        2) 1300 nm: 0.6 dB/km.
    e. Minimum Bandwidth:
        1) 850 nm: 700 MHz-km.
        2) 1300nm: 500 MHz-km.
    f. Color-coded buffer.

g. Minimum Bend Radius, Buffered Fiber: 1 inch.
h. Proof Testing: 100 kpsi.
i. Plenum rated cable shall be used for all interior installations.

3. Cable:
   a. Fiber Count:
      1) Single-mode: 12 fibers per cable, minimum.
      2) Multimode: 12 fibers per cable, minimum.
   b. All Dielectric Construction: No electrically conductive components in fiber optic cable are allowed.
   c. Helically Wound: Buffered fibers helically wound; approximately 5 turns per meter.
   d. Gel-Free: Fibers tight-buffered, not in gel-filled loose-tube.
   e. Core-Locked with no separator tape.
   f. Style: Provide breakout type of cables where neither a fiber distribution frame or fiber center are provided for termination of all fibers.
   g. Strength Member:
      1) Nonconductive; integral part of cable; supports stress of installation and load during use.
      2) Fiberglass epoxy rod, aramid fiber, kevlar.
   h. Minimum Bend Radius:
      1) Short-term Under Tension: 20 times cable diameter.
      2) Long-term Without Tension: 15 times cable diameter.
   i. Identification:
      1) Identify with tags shown on the drawings.
      2) Use waterproof tags and identifications.
   j. Special Features: Cables to be installed in accordance with NEC Article 770 and other applicable codes. Cable supplier is responsible for selecting cable types, including appropriate plenum/riser ratings, required for compliant installation.
   k. Manufacturer: Corning.

B. Innerduct:
   1. Function: Installs into conduit system provided by others, to provide smooth, low-friction path through conduit, with only one cable per path to facilitate changing individual cables.
   2. Features:
      a. Size and Count, in 4-inch conduit: 32 mm; 3.
      b. Type: Annular, corrugated innerduct.
      c. Material: HDPE.
      d. Color: Color code innderducts Orange, Blue, Green, Brown, White, or Grey.
      e. Strength: Minimum 600 pounds tensile strength, with no more than 5 percent ovalization at 600 pounds tension.
      f. Lubrication: Prelubricated.
   3. Manufacturers:
      a. Endocor.
      b. Dura-Line.

C. Fiber Distribution Frame:
   1. Function: Provides industry-standard rack mounting system for interface between fiber optic backbone and equipment cables.

2. Features:
    a. Used in either cross-connect or interconnect configuration.
    b. 23-inch rack for mounting 19-inch rack mount units.
        1) Accommodates up to 576 fiber terminations per frame.
        2) Accepts connector module housing and splice housing within same rack.
    c. Fiber/Wire Management System:
        1) Vertical: 3-inch by 4-inch supports on 8-inch centers vertically on four sides (front LHS, back LHS, front RHS, back RHS).
        2) Horizontal: Supports on 4-inch centers horizontally above and below each termination frame front and back. Support may serve frames immediately above and below.
    d. Mounting Hardware: Accepts standard 19-inch rack for integrated fiber optic system (i.e. hubs, routers, patch panels, etc.).
    e. Splice Trays with Coil Former**:** Former to wind slack cable around, provides controlled long radius bends.
        1) Doors: Pivot down lockable.
        2) Foot and End Caps: Included in final, assembled unit.
        3) Ancillaries: Jumper troughs and covers, cable tie brackets.
3. Manufacturers:
    a. Ortronics.

D. Fiber Centers (Patch Panels):
1. Function: Provides a secure place to terminate fiber optic cables.
2. Features:
    a. Compartments: Two; one for fiber optic cable, one for jumpers to individual equipment.
    b. Coil Former: Former to wind slack cable. Provides controlled long-radius bends.
    c. Connectors: Minimum 24 connectors for entry and exit.
    d. Size: Maximum 18 inches by 12 inches by 4 inches.
    e. Construction: 1.5-millimeter steel with noncorrosive finish.
    f. Mountings: Suitable for permanent attachment as shown, or provide separate mountings that do not obscure covers and doors.
    g. Doors: Required.
3. Manufacturers and Products:
    a. Ortronics; OR-615SMFC.
    b. AT&T.

E. Connectors:
1. Features:
    a. In accordance with requirements of TIA/EIA 568, Section 12.4.3 or Annex F.
    b. Pull Strength: 0.2 N minimum.
    c. Durability: Sustain minimum 500 mating cycles without violating other requirements.
        1) Ferrules: Free-floating low loss ceramic.
        2) Polarizing key on duplex connector systems.
    d. Quantity: Connectorize all fibers on cables.
2. Attenuation:
    a. In accordance with requirements of TIA/EIA 568, Section 12.4.4.

b. Maximum of 0.75 dB per connector pair.
3. Manufacturer: AMP.

F. Jumper Cables:
1. In accordance with requirements of TIA/EIA 568, Section 12.5.
2. Function: To connect from fiber centers to network nodes, such as computer workstations.
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.
4. Cable Configuration:
a. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.
b. Protected with kevlar strength members and enclosed in thermoplastic jacket.
5. Length: Standard, to meet requirements shown, plus minimum 3 meters at workstations.
6. Connectors:
a. As required by Article Connectors.
b. On-axial Pull Strength: 33 N.
c. Normal-to-Axial Pull Strength: 22 N.
7. Communications Management Outlets:
a. In accordance with TIA/EIA 568, Section 12.4.5.
b. Function: Provide organized system for connecting workstations into precabled communications.
c. Cover Plates:
1) Flush and extension mount, as required to provide bend radius and space for coiled cable.
2) Materials: ABS plastic.
3) Color: White, unless otherwise indicated.
4) Identifiers: Color-coded identification strips.
d. Manufacturers and Products:
1) Ortronics; Series II.
2) AMP; Fixed Shroud Duplex (FSD) System.

## 2.04 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare tinned stranded copper (BTC).

## 2.05 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:
1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arcs and Fireproofing:
a. 30-mil, elastomer
b. Manufacturers and Products:
1) Scotch; Brand 77, with Scotch Brand 69 glass cloth tape binder.

2) Plytnount; Plyarc 30, with Plymount Plyglas glass cloth tape binder.

B. Identification Devices:
1. Sleeve: Permanent, PVC, yellow or white, with legible machine-printed black markings.
2. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
3. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:
1. Nylon, Self-Insulated Crimp Connectors:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) Burndy; Insulink.
3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) Burndy; Insulink.
3) ILSCO.

D. Cable Lugs:
1. In accordance with NEMA CC I.
2. Rated 600 volts of same material as conductor metal.
3. Insulated, Locking-Fork, Compression Lugs:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) ILSCO; ILSCONS.
4. Un-insulated Crimp Connectors and Terminators:
a. Manufacturers and Products:
1) Square D; Versitide.
2) Thomas & Betts; Color-Keyed.
3) ILSCO.
5. Un-insulated, Bolted, Two-Way Connectors and Terminators:
a. Manufacturers and Products:
1) Thomas & Betts; Locktite.
2) Burndy; Quiklug.
3) ILSCO.

E. Cable Ties: Nylon, adjustable, self-locking, and reusable.
1. Manufacturers and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation: Thermally stabilized, crosslinked polyofin.
1. Manufacturers and Product: Thomas & Betts; SHRINK-KON.

## 2.06 PULLING COMPOUND

A. Nontoxic, non-corrosive, noncombustible, nonflammable, wax-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

D. Manufacturers and Products:
   1. Ideal Co.; Yellow 77.
   2. Polywater, Inc.
   3. Cable Grip Co.

## PART 3 EXECUTION

### 3.01 GENERAL

A. Conductor installation to be in accordance with NECA 5055.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Tighten screws and terminal bolts in accordance with UL 486A for copper conductors.

E. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

F. Bundling: Where single conductors and cables in manholes, hand holes, vaults, 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 18 inches on center.

G. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

H. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.

I. Cable Tray Installation:
   1. Install wire and cable parallel and straight in tray.
   2. Bundle, in groups, all wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.
   3. Clamp cable bundles prior to making end termination connections.
   4. Separate cables of different voltage rating in same cable tray with barriers.
   5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
      a. Horizontal Runs: 20 feet.
      b. Vertical Runs: 5 feet.

### 3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

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 to 2 inches wide.
2. No. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

| System | Conductor | Color |
|---|---|---|
| All Systems | Equipment Grounding | Green |
| 240/120 Volts<br>Single-Phase, Three-Wire | Grounded Neutral<br>One Hot Leg<br>Other Hot Leg | White<br>Black<br>Red |
| 208Y/120 Volts<br>Three-Phase, Four-Wire | Grounded Neutral<br>Phase A<br>Phase B<br>Phase C | White<br>Black<br>Red<br>Blue |
| 240/120 Volts<br>Three-Phase, Four-Wire<br>Delta, Center Tap<br>Ground on Single-Phase | Grounded Neutral<br>Phase A<br>High (wild) Leg<br>Phase C | White<br>Black<br>Orange<br>Blue |
| 480Y/277 Volts<br>Three-Phase, Four-Wire | Grounded Neutral<br>Phase A<br>Phase B<br>Phase C | Gray<br>Brown<br>Orange<br>Yellow |
| Note:<br>Phase A, B, C implies direction of positive phase rotation. | | |

4. Tracer: Outer covering of white with an identifiable colored strip other than green in accordance with NFPA 70.

B. Conductors Above 600 Volts: 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 to 2 inches wide.
   1. Colors:
      a. Grounded Neutral: White.
      b. Phase A: Brown.
      c. Phase B: Orange.
      d. Phase C: Yellow.

## 3.03 CIRCUIT IDENTIFICATION

A. 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, hand holes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Not Appearing in Circuit Schedules:
   1. Assign circuit name based on device or equipment at load end of circuit.
   2. 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.

C. Method:
   1. Conductors No. 3 AWG and Smaller: Identify with sleeves.
   2. Cables, and Conductors No. 2 AWG and Larger:
      a. Identify with marker plates.
      b. Attach marker plates with nylon tie cord.
   3. Taped-on markers or tags relying on adhesives not permitted.

## 3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors No. 6 AWG and larger unless specifically indicated or approved by Engineer.

C. Connections and Terminations:
   1. Install wire nuts only on solid conductors.
   2. Install nylon self-insulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 6 AWG and smaller.
   3. Install un-insulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 4 AWG through No. 2/0 AWG.
   4. Install un-insulated, bolted, two-way connectors and terminators for power circuit conductors No. 4/0 AWG and larger.
   5. Install un-insulated bolted, two-way connectors for motor circuit conductors No. 12 and larger.
   6. Tape insulates all un-insulated connections.
   7. Place no more than one conductor in any single-barrel pressure connection.
   8. Install crimp connectors with tools approved by connector manufacturer.
   9. Install terminals and connectors acceptable for type of material used.
   10. Compression Lugs
      a. Attach with a tool specifically designed for purpose.
      b. Tool shall provide complete controlled crimp and shall not release until crimp is complete.
      c. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:
   1. Indoors: Use general purpose, flame retardant tape.
   2. Outdoors: Use flame retardant, cold- and weather-resistant tape.

F. Cap spare conductors and conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:
   1. Remove surplus wire, bridle and secure.
   2. Where conductors pass through openings or over edges in sheet metal, remove bums, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Where connections of cables installed under this section are to be made under Section 40_90_00 - Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
5. Cable Protection:
    a. Under Infinite Access Floors: May be installed without bundling.
    b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least 1/2-inch in diameter.
    c. Maintain integrity of shielding of instrumentation cables.
    d. Ensure grounds do not occur because of damage to jacket over the shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

J. Variable Frequency Drive (VFD) Output Power Cable:
1. Install cables in raceway.
2. Terminate the three ground conductors together at the motor and at the ground bus of the VFD.
3. Terminate aluminum armor at motor and at VFD. At motor, terminate shield with cable manufacturer recommended termination kit. Termination shall be to the motor junction box. At the VFD, terminate armor to the invertor drive frame. The termination kit must provide a 360-degree connection of the armor to frame and motor junction box.

## 3.05 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing, tape on 600-volt single conductors and cables except those rated Type TC in manholes, hand holes, vaults, cable trays, and other indicated locations.

B. Install arc and fireproofing tape on 15 kV cables throughout their entire exposed length in manholes, hand holes, vaults, cable trays, and other indicated locations.

C. Wrap conductors of same circuit entering from separate conduit together as a single cable.

D. Follow tape manufacturer's installation instructions.

E. Secure tape at intervals of 5 feet with bands of tape binder. Each tape band shall consist of a minimum of two wraps directly over each other.

## 3.06 UNDERGROUND DIRECT BURIAL CABLE

A. Install in trench as required.

B. Warning Tape: Install approximately 12 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

## 3.07 FIBER OPTIC CABLE AND ACCESSORIES

A. Ensure that installed conduit system conforms to fiber optic system requirements, including:
   1. Conduits and Innerducts: Size and number.
   2. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts can be installed without exceeding manufacturer's limitations.
   3. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.

B. Spare Conduits:
   1. No cables shall be pulled into spare conduits.
   2. Spare conduits need not have innerduct installed.
   3. Expansion Plugs: Seal conduits to stop ingress of water and grit with fabricated expansion plugs.

C. Innerduct:
   1. Installation:
      a. In accordance with manufacturer's recommendations.
      b. In all FOCS fiber optic conduits.
      c. Color Code: Install no more than one innerduct of each color in single conduit.
      d. Terminations: Terminate innerducts in conduit with fabricated termination kits.
   2. Sealing:
      a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
      b. Empty Innerducts: Seal empty innerducts immediately after installation to stop ingress of water and grit with fabricated expansion plugs. Remove plugs as required to install cables.
      c. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.
   3. Identification: Identify innerducts at both ends by methods such as color-coding or waterproof tags wired through innerduct wall.

D. Fiber Optic Cable:
   1. Electrical subcontractor responsibilities include:
      a. Furnish and install conduit/innerducts.
      b. Provide estimates of fiber cable lengths based on actual field installation.
      c. Cable Installation:
         1) Install cables in accordance with manufacturer's requirements.
         2) Install cable directly from shipping reels. Ensure that cable is not:
            a) Dented, nicked, or kinked.
            b) Subjected to pull stress greater, or bend radius less, than manufacturer's specification.
            c) Subjected to treatment that may damage fiber strands during installation.

3) Provide six (6) feet spare length on each end when pulling fiber optic cable.

2. PICS supplier responsibilities include:
   a. Test cable on reels before installation.
   b. Test cables for damage during installation.
   c. Terminate cables.
   d. Test cables after termination.
3. Cables per Conduit or Innerduct: In accordance with NEC conduit fill limitations.
4. If calculation indicates that cable will attenuate signals more than 8 dB, reroute may be allowed, if approved by Engineer.
5. Splices: Install fiber optic cables in unspliced lengths from fiber centers to switches or hubs.
6. Identification: Identify cable on both ends and in access holes and pull points it goes through.
7. Sealing: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion plugs.
8. Access Holes:
   a. Provide supports for cables in access and handholes at minimum 600 mm centers along sides**.**
   b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

E. Fiber Centers:
   1. Install securely in field panels as shown.
   2. Minimum, one per facility having one or more network nodes.

F. Cable Terminations:
   1. Terminate cables in accordance with TIA/EIA 568.
   2. Slack:
      a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
      b. Communications Management Outlets: Minimum, 1-meter slack fiber, coiled neatly in outlet box.
   3. Connectors: Terminate 100 percent fibers in each cable to specified connectors.

G. Ethernet Fiber-to-Copper Transceivers:
   1. Install transceivers in accordance with manufacturer’s instructions.
   2. Location: Install transceivers securely in field panels, close to network nodes and fiber centers.
   3. Power: Energize each transceiver from its field panel’s UPS, if applicable.
   4. Connections:
      a. Connect transceiver to fiber optics and network node.

H. Lace fiber optics neatly in place, routed through wireways.

I. Test and Inspection
   1. In accordance with Section 01 75 17, Commissioning.
   2. Conduit:
      a. Testing and Sealing of Spare Conduits.

b. Conduit and Innerduct Testing:
    1) Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
    2) If any conduit is not unrestricted over full length, advise Engineer.
c. Documentation: Confirm that conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.

3. Cable Testing:
    a. TIA/EIA 568: Demonstrate that 95 percent of the fibers in each cable meet requirements of TIA/EIA 568.
    b. Measure attenuation in both directions, not in one direction only.
    c. For multimode fibers only: Measure attenuation at both 850 nm and 1,300 nm.
    d. Replace and retest cables that do not have specified number of fibers that meet attenuation standards.
    e. The following specific testing is required:
        1) Test cables onsite post delivery.
        2) Test cables following installation.
        3) Test cables following termination.
    f. Test data communication for each link between nodes in the system.

## 3.08 FIELD QUALTTY CONTROL

A. In accordance Section 26_08_00 - Electrical Testing.

END OF SECTION

# SECTION 26_05_26

# GROUNDING

## 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):
      a. C2 - National Electrical Safety Code (NESC).
   2. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).

### 1.02 SUBMITTALS

A. Shop Drawings:
   1. Product Data:
      a. Exothermic weld connectors.
      b. Mechanical connectors.

### 1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

## PART 2 PRODUCTS

### 2.01 GROUND ROD

A. Material: Copper clad.

B. Diameter: 5/8 inch.

C. Length: 20 feet.

### 2.02 GROUND CONDUCTORS

A. As specified in Section 26_05_05 - Conductors.

### 2.03 CONNECTORS

A. Exothermic Weld Type:
   1. Outdoor Weld: Suitable for exposure to elements or direct burial.
   2. Indoor Weld: Utilize low-smoke, low-emission process.
   3. Manufacturers:
      a. Erico Products, Inc.; Cadweld and Cadweld Exolon.
      b. Thermoweld.

B. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.
   1. Manufacturers:
      a. Burndy Corp.
      b. Thomas and Betts Co.

## 2.04 GROUNDING WELLS

A. Ground rod box complete with cast iron riser ring and traffic cover marked GROUND ROD.

B. Manufacturers:
   1. Christy Co.; No. G5.
   2. Lightning and Grounding Systems, Inc.; I-R Series.

# PART 3 EXECUTION

## 3.01 GENERAL

A. Grounding shall be in compliance with NFPA 70 and ANSI C2.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes using minimum 4/O wire size.

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 non-current-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

F. Shielded Control Cables:
   1. Ground shield to ground bus at power supply for analog signal.
   2. Expose shield minimum I inch at termination to field instrument and apply heat shrink tube.
   3. Do not ground control cable shield at more than one point.

## 3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to non current-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.

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.

## 3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to non current-carrying grounding bus.

C. Motors Less Than 10 hp: Furnish mechanical-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Tap motor frame or equipment housing; furnish mechanical-type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

## 3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

## 3.05 GROUNDING WELLS

A. Install inside buildings, asphalt, and paved areas.

B. Install riser ring and cover flush with surface.

C. Place 9 inches crushed rock in bottom of each well.

## 3.06 CONNECTIONS

A. General:
   1. Above grade Connections: Use either exothermic weld or mechanical-type connectors.
   2. Below grade Connections: Install exothermic weld type connectors.

3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:
1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Mechanical Type:
1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

## 3.07 METAL STRUCTURE GROUNDING

A. Ground metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

## 3.08 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each.

B. Ground Rod Floor Protrusion: 4 to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all non current-carrying metal parts, and any metallic raceway grounding bushings to ground rod with No. 6 AWG copper conductor.

## 3.09 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.

C. Bond neutrals of pad-mounted transformers to four locally driven ground rods and buried ground wire encircling transformer and system ground network.

## 3.10 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

## 3.11 INSTRUMENT GROUND - SURGE SUPPRESSION

A. Connect all instrument surge protection with #6 insulated copper ground wire (in conduit where above grade) to closest plant ground system

## 3.12 BONDING

A. Bond to Main Conductor System:
   1. All roof mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails, and other sizeable metal objects.
   2. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object.
   3. Provide air terminals as required.

B. Bond steel columns or major framing members to grounding system per National Electrical Code.

C. Bond each main down conductor to grounding system.

## 3.13 GROUNDING SYSTEM

A. Grounding Conductor:
   1. Completely encircle building structure.
   2. Bury minimum 30 inches below finished grade.
   3. Minimum 2 feet distance from foundation walls.

B. Interconnect ground rods by direct-buried copper cables.

C. Connections:
   1. Install ground cables continuous between connections.
   2. Exothermic welded connections to ground rods, cable trays, structural steel, handrails, and buried and nonaccessible connections.
   3. Provide bolted clamp type mechanical connectors for all exposed secondary connections.
   4. Use bolded offset parapet bases or through-roof concealed base assemblies for air terminal connections.
   5. Provide interconnections with electrical and telephone systems and all underground water and metal pipes.
   6. Provide electric service arrestor ground wire to building water main.

## 3.14 FIELD QUALITY CONTROL

A. As specified in Section 26_08_00 - Electrical Testing.

END OF SECTION

## SECTION 26_05_33

## RACEWAYS

## 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):
      a. Division I - Standard Specifications for Highway Bridges, Fourteenth Edition.
   2. American National Standards Institute (ANSI):
      a. C80.1 - Rigid Steel Conduit-Zinc Coated.
      b. C80.3 - Electrical Metallic Tubing-Zinc Coated.
      c. CS0.5 - Rigid Aluminum Conduit.
      d. C80.6 - Intermediate Metal Conduit (IMC)-Zinc Coated.
   3. American Society for Testing and Materials (ASTM):
      a. A123 El - Standard Specification for Zinc-Coated (Galvanized) Coatings on Iron and Steel Products.
      b. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   4. National Electrical Contractor's Association, Inc. (NECA):
      a. 5055 - Standard of Installation.
   5. National Electrical Manufacturers Association (NEMA):
      a. RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
      b. TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
      c. TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.
      d. TC 6 - PVC and ABS Plastic Utilities Duct for Underground Installation.
      e. VE 1 - Metallic Cable Tray Systems.
   6. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code. (NEC)
   7. Underwriters Laboratories, Inc. (UL):
      a. 1 - Standard for Safety Flexible Metal Conduit.
      b. 6 - Standard for Safety Rigid Metal Conduit.
      c. 360 - Standard for Safety Liquid-Tight Flexible Steel Conduit.
      d. 514B - Standard for Safety Fittings for Conduit and Outlet Boxes.
      e. 514C - Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
      f. 651 - Standard for Safety Schedule 40 and 80 PVC Conduit.
      g. 651A - Standard for Safety Type EB and Rigid PVC Conduit and HDPF Conduit.
      h. 797 - Standard for Safety Electrical Metallic Tubing.
      i. 870 - Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings.
      j. 1242 - Standard for Safety Intermediate Metal Conduit.
      k. 1660 - Standard for Safety Liquid-Tight Flexible Nonmetallic Conduit.

## 1.02 SUBMITTALS

A. Shop Drawings:
   1. Manufacturer's Literature:
      a. Rigid galvanized steel conduit.
      b. Electric metallic tubing.
      c. Rigid aluminum conduit.
      d. PVC Schedule 40 conduit.
      e. PVC-coated rigid galvanized steel conduit.
      f. Flexible metal, liquid-tight conduit.
      g. Flexible, nonmetallic, liquid-tight conduit.
      h. Conduit fittings.
      i. Wireways.
   2. Precast Manholes and Handholes:
      a. Dimensional drawings and descriptive literature.
      b. Traffic loading calculations.
      c. Accessory information.
   3. Cable Tray Systems:
      a. Dimensional drawings, calculations, and descriptive information.
      b. NEMA load/span designation and how it was selected.
      c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
      d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
      e. Layout drawings and list of accessories being provided.
   4. Conduit Layout:
      a. Plan and section type, showing arrangement and location of conduit and duct bank required for:
         1) Low and medium voltage feeder and branch circuits.
         2) Instrumentation and control systems.
         3) Communications systems.
         4) Empty conduit for future use.
      b. Reproducible mylar; scale not greater than 1 inch equals 20 feet.
         1) Equipment and machinery proposed for bending metal conduit.
         2) Method for bending PVC conduit less than 30 degrees.

## 1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

# PART 2 PRODUCTS

## 2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):
   1. Meet requirements of ANSI C80.1 and UL6.
   2. Material: Hot-dip galvanized, with chromated protective layer.

B. Electric Metallic Tubing (EMT):
   1. Meet requirements of ANSI C80.3 and UL 797.
   2. Material: Hot-dip galvanized, with chromated and lacquered protective layer.

C. Rigid Aluminum Conduit:
   1. Meet requirements of ANSI C80.5 and UL 6.
   2. Material: Type 6063, copper-free aluminum alloy.

D. 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.

E. PVC-Coated Rigid Galvanized Steel Conduit:
   1. Meet requirements of NEMA RN 1.
   2. Material:
      a. Conduit: Meet requirements of ANSI C80.1 and UL 6.
      b. PVC Coating: 40 mils nominal thickness, bonded to metal.

F. Flexible Metal, Liquid-Tight Conduit:
   1. UL 360 listed for 105 degrees C insulated conductors.
   2. Material: Galvanized steel, with an extruded PVC jacket.

G. Flexible, Nonmetallic, Liquid-Tight Conduit:
   1. Material: PVC core with fused flexible PVC jacket.
   2. UL 1660 listed for:
      a. Dry Conditions: 80 degrees C insulated conductors.
      b. Wet Conditions: 60 degrees C insulated conductors.
   3. Manufacturers:
      a. Carlon; Carflex or X-Flex.
      b. T & B; Xtraflex LTC or EFC.

## 2.02 FITTINGS

A. Rigid Galvanized Steel and Intermediate Metal Conduit:
   1. General:
      a. Meet requirements of UL 514B.
      b. Type: Threaded, galvanized. Set screw fittings not permitted.
   2. Bushing:
      a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
      b. Manufacturers:
         1) Thomas & Betts; Type BIM.
         2) O-Z/Gedney; Type HB.
   3. Grounding Bushing:
      a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
      b. Manufacturers:
         1) Appleton; Series GIB.
         2) O-Z/Gedney; Type HBLG.

4. Conduit Hub:
    a. Material: Malleable iron with insulated throat.
    b. Manufacturers:
    c. O-Z/Gedney; Series CH.
        1) T & B; Series 370.
5. Conduit Bodies:
    a. Material: Malleable iron, sized as required by NFPA 70.
    b. Manufacturers (For Normal Conditions):
        1) Appleton; Form 35 threaded Unilets.
        2) Crouse-Hinds; Form 7 or 8 threaded condulets.
        3) Killark; Series O Electrolets.
    c. Manufacturers (For Hazardous Locations):
        1) Appleton.
        2) Crouse-Hinds.
        3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting Manufacturers:
    a. Appleton; Type EYF, EYM, or ESU.
    b. Crouse-Hinds; Type EYS or EZS.
    c. Killark; Type EY or EYS.
8. Drain Seal Manufacturers:
    a. Appleton; Type SF.
    b. Crouse-Hinds; Type EYD or EZD.
9. Drain/Breather Fitting Manufacturers:
    a. Appleton; Type ECDB.
    b. Crouse-Hinds; ECD.
10. Expansion Fitting Manufacturers:
    a. Deflection/Expansion Movement:
        1) Appleton; Type DF.
        2) Crouse-Hinds; Type XD.
    b. Expansion Movement Only:
        1) Appleton; Type XJ.
        2) Crouse-Hinds; Type XJ.
11. Cable Sealing Fittings:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. For Conductors With OD of 1/2 Inch or Less: Neoprene bushing at connector entry.
    c. Manufacturers:
        1) Crouse-Hinds; CGBS.
        2) Appleton; CG-S.

B. Electric Metallic Tubing:
1. Meet requirements of UL 514B.
2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
3. Compression Ring: Stainless steel.
4. Coupling Manufacturers:
    a. Appleton; Type 95T.
    b. Crouse-Hinds; Type CPR.
5. Connector Manufacturers:
    a. Appleton; Type 86T.

b. Crouse-Hinds; Type CPR.

C. Rigid Aluminum Conduit:
1. General:
a. Meet requirements of UL 514B.
b. Type: Threaded, copper-free. Set screw fittings not permitted.
2. Insulated Bushing:
a. Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
b. Manufacturer: O-Z/Gedney; Type AB.
3. Grounding Bushing:
a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
b. Manufacturer: O-Z/Gedney; Type ABLG.
4. Conduit Hub:
a. Material: Cast aluminum, with insulated throat.
b. Manufacturers:
c. O-Z/Gedney; Type CHA.
1) T & B; Series 370AL.
5. Conduit Bodies:
a. Manufacturers (For Normal Conditions):
1) Appleton; Form 85 threaded Unilets.
2) Crouse-Hinds; Mark 9 or Form 7-SA threaded condulets.
3) Killark; Series O Electrolets.
b. Manufacturers (For Hazardous Locations):
1) Appleton.
2) Crouse-Hinds.
3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting Manufacturers:
a. Appleton; Type EYF-AL or EYM-AL.
b. Crouse-Hinds; Type EYS-SA or EZS-SA.
c. Killark; Type EY or EYS.
8. Drain Seal Manufacturers:
a. Appleton; Type EYDM-A.
b. Crouse-Hinds; Type EYD-SA or EZD-SA.
9. Drain/Breather Fitting Manufacturers:
a. Appleton; Type ECDB.
b. Crouse-Hinds; ECD.
10. Expansion Fitting Manufacturers:
a. Deflection/Expansion Movement: Steel City; Type DF-A.
b. Expansion Movement Only: Steel City; Type AF-A.
11. Cable Sealing Fittings: To form watertight nonslip cord or cable connection to conduit.
a. Bushing: Neoprene at connector entry.
b. Manufacturer: Appleton CG-S.

D. PVC Conduit and Tubing:
1. Meet requirements of NEMA TC-3.
2. Type: PVC, slip-on.

E. PVC-Coated Rigid Galvanized Steel Conduit:
   1. Meet requirements of UL 514B.
   2. Type: Rigid galvanized steel, PVC coated by conduit manufacturer.
   3. Overlapping pressure sealing sleeves.
   4. Conduit Hangers, Attachments, and Accessories: PVC-coated.

F. Flexible Metal, Liquid-Tight Conduit:
   1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
   2. Insulated throat and sealing O-rings.
   3. Long design type extending outside of box or other device at least 2 inches.
      a. Manufacturer: T & B; Series 5300.

G. Flexible, Nonmetallic, Liquid-Tight Conduit: Meet requirements of UL 514B.
   1. Type: One-piece fitting body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
   2. Manufacturers:
      a. Carlon; Type LT.
      b. Kellems; Polytuff.
      c. T & B; LT Series.

H. Watertight Entrance Seal Device:
   1. New Construction:
      a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
      b. Manufacturer: O-Z/Gedney; Type FSK or WSK, as required.
   2. Gored-Hole Application:
      a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
      b. Manufacturer: O-Z/Gedney; Series CSM.

I. Hazardous Locations: Approved for use in the atmosphere involved.
   1. Manufacturer: Crouse-Hinds; Type ECGJH.

J. Corrosive Locations:
   1. Material: 40-mil PVC-coated rigid steel.
   2. Manufacturers:
      a. Robroy Industries.
      b. Carlon.
      c. Crouse-Hinds.

## 2.03 WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, with removable, hinged cover.

C. Rating: Outdoor raintight if outdoor, and indoor if indoor.

D. Finish: Gray, baked enamel.

E. Manufacturers:
   1. Square D.
   2. B-Line Systems, Inc.

## 2.04 CABLE TRAYS

A. Meet requirements of NEMA VE 1.

B. Type: Ladder of welded construction.

C. Material: Copper-free aluminum alloy 6063-T6 finish.

D. Cover: Louvered, minimum 0.40-inch thick aluminum.

E. Barrier Strip: Vertical, solid type, with horizontal fittings and strip clamps.

F. Fittings of same cross-sectional tray area, and hardware of same material as cable tray.

G. Tray Grounding: Conform to NFPA 70 and NEMA VE 1.

H. Provide next higher NEMA VE 1 class designation than required for support of designed span length.

I. Design Loads: Use working load adequate for actual cable installed plus 50 percent additional weight allowance for future cables plus 200-pound concentrated static load applied between side rails at midspan, with safety factor of 2 in accordance with NEMA VE 1, Table 3-1.

J. Expansion Joints: NEMA VE 1 for 50 degrees F maximum temperature variation.

K. Furnish Cable Tray with no sharp edges, burrs, or weld projections.

L. Manufacturers:
   1. B-Line Systems, Inc.
   2. Square-D.
   3. P. W. Industries.

## 2.05 PRECAST MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

B. Loading: AASHTO Division 1, H-20 in accordance with ASTM C857.

C. Access: Provide cast concrete 6- or 12-inch risers and access hole adapters between top of manhole and finished grade at required elevations.

D. Drainage:
   1. Slope floors toward drain points, leaving no pockets or other non-draining areas.

2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and 4-inch minimum outlet and outlet pipe.

E. Raceway Entrances:
   1. Provide on all four sides.
   2. For raceways to be installed under this Contract, provide knockout panels or precast individual raceway openings.
   3. At entrances where raceways are to be installed by others, provide minimum 12-inch high by 24-inch wide knockout panels for future raceway installation.

F. Embedded Pulling Iron:
   1. Material: 3/4-inch diameter stock, fastened to overall steel reinforcement before concrete is placed.
   2. Location:
      a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
   3. Floor: Centered below manhole or handhole cover.

G. Cable Racks:
   1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
   2. Wall Attachment:
      a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
      b. Insert Spacing: Maximum 3-foot on center entire inside perimeter of manhole.
      c. Arrange so that spare raceway ends are clear for future cable installation.

H. Manhole Frames and Covers:
   1. Material: Machined cast iron.
   2. Diameter: 32 inches.
   3. Cover Type: Indented, solid top design, with two drop handles each.
   4. Cover Loading: AASHTO Division I, H-20.
   5. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
      a. Above 600 Volts: ELECTRIC HV.
      b. 600 Volts and Below: ELECTRIC LV.
      c. TELEPHONE.

I. Handhole Frames and Covers:
   1. Material: Steel, hot-dipped galvanized.
   2. Cover Type: Solid, bolt-on, of checkered design.
   3. Cover Loading: H-20.
   4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
      a. 600 Volts and Below: ELECTRIC LV.
      b. TELEPHONE.

J. Hardware: Steel, hot-dip galvanized.

K. Furnish knockout for ground rod in each handhole and manhole.

L. Manufacturers:
   1. U.S. Precast.
   2. Brooks Products, Inc.
   3. Penn-Cast Products, Inc.
   4. Concrete Conduit Co.
   5. Associated Concrete Products, Inc.
   6. Utility Vault Co.
   7. Pipe, Inc.

## 2.06 ACCESSORIES

A. Duct Bank Spacers:
   1. Type: Nonmetallic, interlocking, for multiple conduit sizes.
   2. Suitable for all types of conduit.
   3. Manufacturer: Underground Device, Inc.; Type WUNPEECE.

B. Identification Devices:
   1. Raceway Tags:
      a. Material: Permanent, nylon.
      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.
      b. Color: Red.
      c. Width: Minimum 6 inches.
      d. Designation: Warning on tape that electric circuit is located below tape.
      e. Manufacturers:
         1) Blackburn, Type RT.
         2) Griffolyn Co.
   3. Buried Raceway Marker:
      a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
      b. Designation: Incise to depth of 3/32 inch, ELECTRIC CABLES. in letters 1/4-inch high.
      c. Minimum Dimension: 1/4-inch thick, 10 inches long, and 3/4-inch wide.

C. Raceway Coating:
   1. Material: Bitumastic or plastic tape coating.
   2. Manufacturers:
      a. Koppers bitumastic; No. 505.
      b. Scotchwrap; No. 51, plastic tape.

D. Wraparound Duct Band:
   1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
   2. Manufacturer: Raychem; Type TWDB.

## PART 3 EXECUTION

### 3.01 GENERAL

A. Conduit and Tubing sizes shown are based on the use of copper conductors. Reference Section 26_05_05 - Conductors, concerning conduit sizing for aluminum conductors.

B. All installed Work shall comply with NECA 5055.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Aluminum Conduit: Do not install in direct contact with concrete.

G. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

H. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

I. Group raceways installed in same area.

J. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

K. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

L. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

M. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.

N. Install watertight fittings in outdoor, underground, or wet locations.

O. Paint threads, before assembly of fittings, of galvanized conduit or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

P. All metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

Q. Do not install raceways in concrete equipment pads, foundations, or beams.

R. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

S. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

## 3.02 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum cover 1-1/2 inches.

B. Provide support during placement of concrete to ensure raceways remain in position.

C. Floor Slabs:
   1. Outside diameter of conduit not to exceed one-third of the slab thickness.
   2. Separate conduit by minimum six times conduit outside diameter, except at crossings.

## 3.03 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exterior, Exposed: Rigid galvanized steel.

C. Interior, Exposed:
   1. Rigid galvanized steel.
   2. Electric metallic tubing for ceiling portion of lighting circuits in a conditioned environment.

D. Interior, Concealed (Not Embedded in Concrete):
   1. Rigid galvanized steel.
   2. PVC Schedule 40 for frame walls.
   3. Electric metallic tubing for block walls.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

F. Direct Earth Burial: PVC-coated rigid galvanized steel.

G. Concrete-Encased Raceways: PVC Schedule 40.

H. Under Slabs-On-Grade: PVC Schedule 40.

I. Corrosive Areas, Exterior: PVC-coated rigid galvanized steel.

J. Corrosive Areas, Interior: PVC Schedule 80.

K. Lightning Protection: PVC Schedule 40.

## 3.04 CONNECTIONS

A. 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:
   1. Conduit Size 4 Inches or Less: Flexible metal, liquid-tight conduit.
   2. Conduit Size Over 4 Inches: Nonflexible.

3. Corrosive Areas: Flexible, nonmetallic, liquid or PVC-coated metallic, liquid-tight.
4. Length: 18-inch minimum, 60-inch maximum, of sufficient length to allow movement or adjustment of equipment.

B. Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Transition From Underground or Concrete Embedded to Exposed: PVC Coated Rigid galvanized steel conduit.

E. Under Equipment Mounting Pads: Rigid galvanized steel conduit.

F. Exterior Light Pole Foundations: Rigid galvanized steel conduit.

## 3.05 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Fire-stop openings around penetrations to maintain fire-resistance rating.

D. Apply single layer of wraparound duct band to all metallic conduit in contact with concrete floor slabs to a point 2 inches above concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

F. Entering Structures:
1. General: Seal raceway at the first box or outlet with minimum 2 inches thick expandable plastic compound to prevent the entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
    a. Provide a watertight seal.
    b. Without Concrete Encasement: Install watertight entrance seal device on each side.
    c. With Concrete Encasement: Install watertight entrance seal device on the accessible side.
    d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
    e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
3. Heating, Ventilating, and Air Conditioning Equipment:
    a. Penetrate equipment in area established by manufacturer.
    b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.

c. Seal penetration with silicone type sealant fire stopping rated.

4. Corrosive-Sensitive Areas:
   a. Seal all conduit passing through chlorine and ammonia room walls.
   b. Seal all conduit entering equipment panel boards and field panels containing electronic equipment.
   c. Seal penetration with silicone type sealant fire stopping rated.
5. Existing or Precast Wall (Underground): Core drill wall and install a watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
   a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
   b. Fill space between raceway and sleeve with an expandable plastic compound on each side.
7. Manholes and Handholes:
   a. Metallic Raceways: Provide insulated grounding bushings.
   b. Nonmetallic Raceways: Provide bell ends flush with wall.
   c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

## 3.06 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 40 percent extra space for future conduit.

C. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
   1. Wood: Wood screws.
   2. Hollow Masonry Units: Toggle bolts.
   3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
   4. Steelwork: Machine screws.

D. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

## 3.07 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:
   1. Bends 30-Degree and Larger: Provide factory-made elbows.
   2. 90-Degree Bends: Provide rigid steel elbows.
   3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

## 3.08 EXPANSION/DEFLECTION FITTINGS

A. Provide on all raceways at all structural expansion joints, and in long tangential runs.

B. Provide expansion/deflection joints for 50 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

## 3.09 PVC CONDUIT

A. Solvent Welding:
   1. Provide manufacturer recommended solvent; apply to all joints.
   2. Install such that joint is watertight.

B. Adapters:
   1. PVC to Metallic Fittings: PVC terminal type.
   2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belied-End Conduit: Bevel the unbelled end of the joint prior to joining.

## 3.10 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

B. Provide PVC boot to cover all exposed threading.

## 3.11 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

## 3.12 CABLE TRAYS

A. Install in accordance with Application Information Section of NEMA VE 1.

B. Provide accessories as necessary for a complete system.

C. Install such that joints are not made at support brackets.

D. Install horizontal section support brackets between support point and quarter point of tray span.

E. Provide ceiling trapeze for all horizontal cable tray.

F. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.

G. Provide expansion joints in accordance with NEMA VE 1 for 50 degrees F maximum temperature variation.

H. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8 inch in 10 feet and within a cumulative maximum of 1/2 inch.

I. Install vertical tray plumb within a tolerance of 1/8 inch in 10 feet.

J. Install without exposed raw edges.

K. Maintain 9-inch vertical separation between multi-tiered trays having a common support, and at all crossover locations.

L. Provide bonding jumper at each expansion joint and adjustable connection.

M. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

## 3.13 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Provide manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Sheet Metal Boxes, Cabinets, and Enclosures:
   1. Rigid Galvanized Conduit:
      a. Provide one lock nut each on inside and outside of enclosure.
      b. Install grounding bushing.
      c. 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.
      d. Install insulated bushing on ends of conduit where grounding is not required.
      e. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   2. Electric Metallic Tubing: Provide gland compression, insulated connectors.
   3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
   4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.

5. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
6. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut.

C. Motor Control Center, Switchboard, Switchgear, and Free-Standing Enclosures: Terminate conduit entering bottom with grounding bushing; provide a grounding jumper extending to equipment ground bus or grounding pad.

## 3.14 UNDERGROUND RACEWAYS

A. This section applies to all underground conduit installations including underground installation on open field, under the slab, under the roadways, etc.

B. 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.

C. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.

D. Make routing changes as necessary to avoid obstructions or conflicts.

E. Couplings: In multiple conduit runs, stagger so that couplings in adjacent runs are not in same transverse line.

F. Union type fittings not permitted.

G. Spacers:
1. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. 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.

H. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

I. Installation with Other Piping Systems:
1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Metallic Raceway Coating: At couplings and joints and along entire length, apply wraparound duct band with one-half tape width overlap to obtain two complete layers.

K. Concrete Encasement: As specified in Section 03_30_01 – Concrete Work.
1. Concrete Color: Gray, dust top of concrete duct bank with powdered red concrete dye before concrete sets and trowel dry onto top of duct bank.

L. Backfill:
1. As specified in Section 31_23_23 – Backfilling.

2. Do not backfill until inspected by Engineer.

## 3.15 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade back to original state.

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.

D. Grounding: As specified in Section 26_05_26 - Grounding.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

## 3.16 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Paragraph Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

## 3.17 IDENTIFICATION DEVICES

A. Raceway Tags:
   1. Identify origin and destination.
   2. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed Raceway, whether in ceiling space or surface mounted.
   3. Provide nylon strap for attachment.

B. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of runs.

C. Buried Raceway Markers:
   1. Install at grade to indicate direction of underground raceways.
   2. Install at all bends and at intervals not exceeding 100 feet in straight runs.
   3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

## 3.18 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over all conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up damage to coating on PVC-coated conduit with patching compound approved by manufacturer.

END OF SECTION

## SECTION 26_08_00

## ELECTRICAL TESTING

## 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):
      a. 450 - Recommended Practice for Maintenance, Testing, and Replacement of Large lead Storage Batteries for Generator Stations and Substations.
      b. C2 - National Electrical Safety Code.
      c. C37.20.1 - Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
      d. C37.20.2 - Metal-Clad and Station-Type Cubicle Switchgear.
      e. C37.20.3 - Metal-Enclosed Interrupter Switchgear.
      f. C62.33 - Standard Test Specifications for Varistor Surge- Protective Devices.
   2. American Society for Testing and Materials (ASTM):
      a. D665 - Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
      b. DS77 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
      c. D923 - Standard Test Method for Sampling Electrical Insulating Liquids.
      d. D924 - Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
      e. D971 - Standard Test Method for Interfacial Tension of 0.1 Against Water by the Ring Method.
      f. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
      g. D1298 - Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
      h. D1500 - Standard Test Method for ASTM Color of Petroleum Products.
      i. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
      j. D1533 - Standard Test Methods for Water in Insulating Liquids.
      k. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
      l. D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop- Weight Method.
   3. Institute of Electrical and Electronics Engineers (IEEE):
      a. 43 - Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
      b. 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators.

c. 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
d. 95 - Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage.
e. 118 - Standard Test Code for Resistance Measurement.
f. 400 - Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.

4. National Electrical Manufacturers Association (NEMA):
   a. AB 4 - Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2 -Deadfront Distribution Switchboards.
   c. WC 7 - Cross-Linked-Thermosetting-Polyethylene-Wire and Cable for the Transmission and Distribution of Electrical Energy.
   d. WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
5. International Electrical Testing Association (NETA): ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
6. National Fire Protection Association (NFPA):
   a. 70 - National Electrical Code (NEC).
   b. 70E - Standard for Electrical Safety Requirements for Employee Workplaces.

## 1.02 SUBMITTALS

A. Administrative Submittals: Submit 30 days prior to performing inspections or tests:
   1. Schedule for performing inspection and tests.
   2. List of references to be used for each test.
   3. Sample copy of equipment and materials inspection form(s).
   4. Sample copy of individual device test form.
   5. Sample copy of individual system test form.

B. Quality Control Submittals: Submit within 30 days after completion of test:
   1. Test or inspection reports and certificates for each electrical item tested.

C. Contract Closeout Submittals:
   1. Operation and Maintenance Data:
      a. In accordance with Section 01_78_24 - Operation and Maintenance Data.
      b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in operation and maintenance manual.

## 1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:
   1. Corporately and financially independent organization functioning as an unbiased testing authority.
   2. Professionally independent of manufacturers, suppliers, and installers, of electrical equipment and systems being tested.
   3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.

4. Supervising engineer accredited as Certified Electrical Test Technologist by National Institute for Certification of Engineering Technologists (NICET), or International Electrical Testing Association and having a minimum of 5 years testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA Title 29, Part 1907 criteria for accreditation of testing laboratories or a full Member Company of International Electrical Testing Association.

B. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

## 1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment are to be:
1. Scheduled with engineer prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.

# PART 2 PRODUCTS

Not Used.

# PART 3 EXECUTION

## 3.01 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements of Section 01_75_17 -Commissioning.

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, NFPA 70E, and ANSI C2.

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. Inform Engineer of working clearances not in accordance with NFPA 70.

M. Investigate and repair or replace:
   1. Electrical items that fail tests.
   2. Active components not operating in accordance with manufacturer's instructions.
   3. Damaged electrical equipment.

N. 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 dented surfaces.
   5. Repair or replace, as determined by Engineer, poor fitting doors and panel sections.
   6. Repair or replace improperly operating latching, locking, or interlocking devices.
   7. Replace missing or damaged hardware.
   8. Finish:
      a. Provide matching paint and touch up scratches and mars.
      b. If required due to extensive damage, as determined by Engineer, refinish the entire assembly.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents.

P. Replace transformer insulating oil not in compliance with ASTM D923.

## 3.02 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:
   1. Insulator damage and contaminated surfaces.
   2. Proper barrier and shutter installation and operation.
   3. Proper operation of indicating devices.
   4. Improper blockage of air cooling passages.
   5. Proper operation of drawout elements.
   6. Integrity and contamination of bus insulation system.
   7. Check Door and Device Interlocking System By:
      a. Closure attempt of device when door is in OFF or OPEN position.
      b. Opening attempt of door when device is in ON or CLOSED position.
   8. Check Key Interlocking Systems for:
      a. Key captivity when device is in ON or CLOSED position.
      b. Key removal when device is in ON or CLOSED position.
      c. Closure attempt of device when key has been removed.
      d. Correct number of keys in relationship to number of lock cylinders.
      e. Existence of other keys capable of operating lock cylinders.
         1) Destroy duplicate sets of keys.
   9. Check Nameplates for Proper Identification of:
      a. Equipment title and tag number with latest one-line diagram.
      b. Pushbutton.
      c. Control switch.
      d. Pilot light.
      e. Control relay.
      f. Circuit breaker.
      g. Indicating meter.
   10. Verify that fuse and circuit breaker ratings, sizes, and types conform to those specified,
   11. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench thermographic survey applied to bolted joints.
      a. Ohmic value to be zero.
      b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
      c. Thermographic survey temperature gradient of 2 degrees C, or less.
   12. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
      a. Closure attempt for locked open devices.
      b. Opening attempt for locked closed devices.
      c. Key exchange to operate devices in OFF-NORMAL positions.
   13. Verify performance of each control device and feature.
   14. Control Wiring:
      a. Compare wiring to local and remote control and protective devices with elementary diagrams.
      b. Proper conductor lacing and bundling.

c. Proper conductor identification.
d. Proper conductor logs and connections.

15. Exercise active components.
16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:
1. Insulation Resistance Tests:
a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.1.1.
b. Each phase of each bus section.
c. Phase-to-phase and phase-to-ground for 1 minute.
d. With switches and breakers open.
e. With switches and breakers closed.
f. Control wiring except that connected to solid state components.
g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Overpotential Tests:
a. Applied ac or dc voltage and test procedure in accordance with ANSI C37.20.3 and NEMA PB 2.
b. Each phase of each bus section.
c. Phase-to-phase and phase-to-ground for 1 minute.
d. Test results evaluated on a pass/fail basis.
3. Current Injection Tests:
a. For entire current circuit in each section.
b. Secondary injection for current flow of 1 ampere.
c. Test current at each device.
4. Control Wiring:
a. Apply secondary voltage to control power and potential circuits.
b. Check voltage levels at each point on terminal boards and each device terminal.
5. Operational Test:
a. Initiate control devices.
b. Check proper operation of control system in each section.

## 3.03 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:
1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify that tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter DC voltage in accordance with NETA ATS, Table 7.2.3 for each:
         1) Winding-to-winding.
         2) Winding-to-ground.
      b. 10-minute test duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      c. Results temperature corrected in accordance with NETA ATS, Table 7.2.4.
      d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
      e. Insulation resistance test results to compare within 1 percent of adjacent windings.
   2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

## 3.04 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Inspect Each Individual Exposed Power Cable No. 6 and Larger for:
      a. Physical damage.
      b. Proper connections in accordance with single-line diagram.
      c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
      d. Color coding conformance with specifications.
      e. Proper circuit identification.
   2. Mechanical Connections for:
      a. Proper lug type for conductor material.
      b. Proper lug installation.
      c. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
   3. Shielded Instrumentation Cables for:
      a. Proper shield grounding.
      b. Proper terminations.
      c. Proper circuit identification.
   4. Control Cables for:
      a. Proper termination.
      b. Proper circuit identification.
   5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:
   1. Insulation Resistance Tests:
      a. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for 1 minute.
      b. Evaluate ohmic values by comparison with conductors of same length and type.
      c. Investigate values less than 50 megohms.
      d. Utilize 1,000V dc megohmmeter for 600V insulated conductors.
   2. Continuity test by ohmmeter method to ensure proper cable connections.

## 3.05 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:
   1. Proper mounting.
   2. Proper conductor size.
   3. Feeder designation according to nameplate and one-line diagram.
   4. Cracked casings.
   5. Connection bolt torque level in accordance with NETA ATS, Table 10.1.
   6. Operate breaker to verify smooth operation.
   7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
   8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Utilize 1,000-volt dc megohmmeter for 480- and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
      b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
      c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
      d. Test values to comply with NETA ATS, Table 10.2.
   2. Contact Resistance Tests:
      a. Contact resistance in microhms across each pole.
      b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
   3. Primary Current Injection Test to Verify:
      a. Long-time minimum pickup and delay.
      b. Short-time pickup and delay.
      c. Ground fault pickup and delay.
      d. Instantaneous pickup by run-up or pulse method.
      e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      f. Trip times shall be within limits established by NEMA AB 4, Table 5-3.
      g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4.

## 3.06 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:
   1. Visually Check Each Relay for:
      a. Tight cover gasket and proper seal.
      b. Unbroken cover glass.
      c. Condition of spiral spring and contacts.
      d. Disc clearance.
      e. Condition of case shorting contacts if present.

2. Mechanically Check Each Relay for:
    a. Freedom of movement.
    b. Proper travel and alignment.
3. Verify That Each Relay:
    a. Complies with Contract Documents and application.
    b. Is set in accordance with recommended settings.

B. Electrical Tests:
1. Insulation resistance test on each circuit to frame except for solid state devices.
2. Tests on Nominal Recommended Setting for:
    a. Pickup parameters on each operating element.
    b. Timing at three points on time-current curve.
    c. Pickup target and seal-in units.
    d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
4. Current Injection Tests:
    a. For entire current circuit in each section.
    b. Secondary injection for current flow of 1 ampere.
    c. Test current at each device.

## 3.07 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:
1. Visually Check Current, Potential, and Control Transformers for:
    a. Cracked insulation.
    b. Broken leads or defective wiring.
    c. Proper connections.
    d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically That:
    a. Grounding and shorting connections have good contact.
    b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:
1. Current Transformer Tests:
    a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts DC for 30 seconds.
    b. Polarity test.
2. Potential Transformer Tests:
    a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 7.1.1 for 1 minute on:
        1) Winding-to-winding.
        2) Winding-to-ground.
    b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

## 3.08 METERING

A. Visual and Mechanical Inspection:
   1. Verify meter connections in accordance with appropriate diagrams.
   2. Verify meter multipliers.
   3. Verify that meter types and scales conform to Contract Documents.
   4. Check calibration of meters at cardinal points.
   5. Check calibration of electrical transducers.

## 3.09 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:
   1. Equipment and circuit grounds in motor control centers, panelboards, switchboards, and switchgear assemblies for proper connection and tightness.
   2. Ground bus connections in motor control centers, panelboards, switchboards, and switchgear assemblies for proper termination and tightness,
   3. Effective transformer core and equipment grounding.
   4. Accessible connections to grounding electrodes for proper fit and tightness.
   5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:
   1. Fall-of-Potential Test:
      a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
      b. Main ground electrode system resistance to ground to be no greater than 5 ohms.
   2. Two-Point Direct Method Test:
      a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
      b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

## 3.10 GROUND FAULT SYSTEMS

A. Inspection and Testing Limited to:
   1. Zero sequence grounding systems.
   2. Residual ground fault systems.

B. Visual and Manual Inspection:
   1. Neutral Main Bonding Connection to Ensure:
      a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
      b. Ground strap sensing system is grounded through sensing device.
      c. Neutral ground conductor is solidly grounded.
   2. Verify that control power has adequate capacity for system.
   3. Manually Operate Monitor Panels for:
      a. Trip test.
      b. No trip test.
      c. Nonautomatic rest.

4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:
1. Test system neutral insulation resistance with neutral ground link removed. System neutral insulation resistance minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pickup current, or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.

D. Test system operation at 55 percent rated control voltage, if applicable.

E. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

## 3.11 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower and larger.

B. Visual and Mechanical Inspection:
1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate Motor and Check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionality and proper operation.
   e. Excessive vibration.
5. Check operation of space heaters.

C. Electrical Tests:
1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for:
      1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.

4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.
5. Overpotential Tests:
    a. Applied dc voltage in accordance with IEEE 95.
    b. Limited to 4,000-volt motors rated 1,000 horsepower and greater.
    c. Test results evaluated on pass/fail basis.

## 3.12 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:
1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check Door and Device Interlocking System By:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check Key Interlocking Systems for:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in OFF or OPEN position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check Nameplates for Proper Identification Of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbuttons.
    c. Control switches.
    d. Pilot lights.
    e. Control relays.
    f. Circuit breakers.
    g. Indicating meters.
10. Verify that fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify that current and potential transformer ratios conform to Contract Documents.
12. Check Bus Connections for High Resistance by Low Resistance Ohmmeter and Thermographic Survey:
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
    c. Thermographic survey temperature gradient of 2 degrees Celsius, or less.
13. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
14. Verify performance of each control device and feature furnished as part of the motor control center.

15. Control Wiring.
16. Compare wiring to local and remote control, and protective devices with elementary diagrams.
17. Check for proper conductor lacing and bundling.
18. Check for proper conductor identification.
    a. Check for proper conductor lugs and connections.
19. Exercise active components.
20. Inspect Contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of all connections.
21. Compare overload heater rating with full-load current for proper size.
22. Compare motor protector and circuit breaker with motor characteristics and power factor correction capacitors for proper size.
23. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:
    1. Insulation Resistance Tests:
        a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
        b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
        c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
        d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
        e. Test values to comply with NETA ATS, Table 10.2.
    2. Overpotential Tests:
        a. Maximum applied ac or dc voltage in accordance with NETA ATS, Table 7.1.2.
        b. Phase-to-phase and phase-to-ground for 1 minute for each phase of each bus section.
        c. Test results evaluated on pass/fail basis.
    3. Current Injection Through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
        a. Trip time in accordance with manufacturer's published data.
        b. Investigate values in excess of 120 seconds.
    4. Control Wiring Tests:
        a. Apply secondary voltage to control power and potential circuits.
        b. Check voltage levels at each point on terminal boards and each device terminal.
        c. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components.
            1) Insulation resistance to be 1 megohm minimum.
    5. Operational test by initiating control devices to affect proper operation.

## 3.13 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:
    1. Check doors and panels for proper interlocking.

2. Check connections for high resistance by low resistance ohmmeter.
3. Check positive mechanical and electrical interlock between normal and alternate sources.
4. Check for Proper Operation:
    a. Manual transfer function switch.
    b. Generator under load and non-load conditions.
    c. Auto-exerciser of generator under load and no-load conditions.
5. Verify settings and operation of control devices.

B. Electrical Tests:
1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2 for each phase with switch CLOSED in both source positions.
    b. Phase-to-phase and phase-to-ground for 1 minute.
    c. Test values in accordance with manufacturer's published data.
2. Contact Resistance Test:
    a. Contact resistance in microhms across each switch blade for both source positions.
    b. Investigate values exceeding 500 micro-ohms.
    c. Investigate values deviating from adjacent pole by more than 50 percent.
3. Set and Calibrate in Accordance with Specifications:
    a. Voltage and frequency sensing relays.
    b. Time delay relays.
    c. Engine start and shutdown relays.
4. Perform Automatic Transfer Tests By:
    a. Simulating loss of normal power.
    b. Return to normal power.
    c. Simulating loss of alternate power.
    d. Simulating single-phase conditions for normal and alternate sources.
5. Monitor and Verify Operation and Timing Of:
    a. Normal and alternate voltage sensing relays.
    b. Engine start sequence.
    c. Timing delay upon transfer and retransfer.
    d. Engine cool down and shutdown.
    e. Interlocks and limit switch functions.
    f. Engine cool down and shutdown feature.

## 3.14 BATTERY SYSTEM

A. Visual and Mechanical Inspection:
1. Physical damage and electrolyte leakage.
2. Evidence of corrosion.
3. Intercell bus link integrity.
4. Battery cable insulation damage and contaminated surfaces.
5. Operating conditions of ventilating equipment.
6. Visual check of electrolyte level.

B. Electrical Tests:
1. Measure:
    a. Bank charging voltage.
    b. Individual cell voltage.

c. Electrolyte specific gravity in each cell.
d. Measured test values to be in accordance with manufacturer's published data.

2. Verify During Recharge Mode:
   a. Charging rates from charger.
   b. Individual cell acceptance of charge.
3. Load tests for integrity and capacity; test values in accordance with ANSI 450.

## 3.15 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:
   1. Adequate clearances between arrestors and enclosures.
   2. Ground connections to ground bus or electrode.

B. Electrical Tests:
   1. Varistor Type Arrestors:
      a. Clamping voltage test.
      b. Rated RMS voltage test.
      c. Rated dc voltage test.
      d. Variator arrester test values in accordance with ANSI C62.33, Sections 4.4 and 4.7.

## 3.16 STANDBY AND EMERGENCY GENERATOR SYSTEMS

A. Visual and Mechanical Inspection:
   1. Proper grounding.
   2. Blockage of ventilating passageways.
   3. Proper operation of jack water heaters.
   4. Integrity of engine cooling and fuel supply systems.
   5. Excessive mechanical and electrical noise.
   6. Overheating of engine or generator.
   7. Proper installation of vibration isolators.
   8. Proper cooling liquid type and level.
   9. Operate Engine-Generator and Check for:
      a. Excessive mechanical and electrical noise.
      b. Overheating.
      c. Correct rotation.
      d. Check resistance temperature detectors or generator inherent thermal protectors for functionality and proper operation.
      e. Excessive vibration.
   10. Verify that voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
   11. Proper operation of meters and instruments.
   12. Compare generator nameplate rating and connection with one-line diagram.
   13. Verify engine-generator operation with adjustable frequency drives energized and operating under normal load conditions.

B. Electrical and Mechanical Tests:
   1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
      a. Transfer switch operation.

b. Automatic starting operation.
c. Operating ability of engine-generator.
d. Overcurrent devices capability to withstand inrush currents.

2. Phase rotation tests.
3. Test Engine Protective Shutdown Features for:
   a. Low oil pressure.
   b. Overtemperature.
   c. Overspeed.
4. Vibration base-line test on generator sets rated above 250 kW; levels in accordance with manufacturer's recommendations.
5. Load bank test with reactors and resistors adjusted to 80 percent power factor for each load step. Record voltage, frequency, load current, oil pressure, and engine coolant temperature at 15-minute intervals:
   a. 25 percent applied load for 30 minutes.
   b. 50 percent applied load for 30 minutes.
   c. 75 percent applied load for 30 minutes.
   d. 100 percent applied load for 3 hours.
   e. Load test results to demonstrate ability of unit to deliver rated load for test period.
6. One-Step Rated kW Load Pickup Test:
   a. Perform test immediately after performing load bank test.
   b. Apply rated load, minus largest rated horsepower motor, to generator.
   c. Start largest rated horsepower motor and record voltage drop for 20 cycles minimum with high-speed chart recorder or digital storage oscilloscope.
   d. Compare voltage drop with maximum allowable voltage dip for specified starting situation.

## 3.17 THERMOGRAPHIC SURVEY

A. Provide a thermographic survey of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:
   1. Medium voltage switchgear and transformer.
   2. Switchboard.
   3. Low voltage motor control center.
   4. Panelboard.

B. Provide a thermographic survey of feeder conductors No. 2 and larger terminating at:
   1. Motors rated 30 horsepower and larger.
   2. Medium and low voltage disconnect switches.
   3. Transfer switches.
   4. Engine-generators.

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading.

E. Do not perform survey on equipment operating at less than 20 percent of rated connected operating load.

F. Utilize Thermographic Equipment Capable Of:
   1. Detecting emitted radiation.
   2. Converting detected radiation to visual signal.
   3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees Celsius.

G. Temperature Gradients Of:
   1. 3 degrees Celsius to 7 degrees Celsius indicates possible deficiency that warrants investigation.
   2. 7 degrees Celsius to 15 degrees Celsius indicates deficiency that is to be corrected as time permits.
   3. 16 degrees Celsius and above indicates deficiency that is to be corrected immediately.

H. Provide Written Report Of:
   1. Areas surveyed and the resultant temperature gradients.
   2. Locations of areas having temperature gradients of 3 degrees Celsius or greater.
   3. Cause of heat rise and actions taken to correct the cause of heat rise.
   4. Detected phase unbalance.

END OF SECTION

## SECTION 26_20_00

## ELECTRICAL MOTORS

# PART 1 GENERAL

## 1.01 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and any deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

## 1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Anti-Friction Bearing Manufacturers' Association (AFBMA):
      a. 9 - Load Ratings and Fatigue Life for Ball Bearings.
      b. 11 - Load Rating and Fatigue Life for Roller Bearings.
   2. American National Standards Institute (ANSI):
      a. C50.41 - Polyphase Induction Motors for Power Generating Stations.
   3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 85 - Test Procedure for Airborne Sound Measurements on Rotating Machines.
      b. 112 - Standard Test Procedures for Polyphase Induction Motors and Generators.
      c. 114 - Standard Test Procedures for Single-Phase Induction Motors.
      d. 620 - Guide for Construction and Interpretation of Thermal Limit Curves for Squirrel-Cage Motors Over 500 Horsepower.
      e. 841 - Recommended Practice for Chemical Industry Severe-Duty Squirrel-Cage Induction Motors, 600V and Below.
   4. National Electrical Manufacturers Association (NEMA):
      a. MG 1 - Motors and Generators.
      b. MG 13 - Frame Assignments for Alternating Current Integral Horsepower Induction Motors.
      c. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
   5. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code. (NEC)
   6. Underwriters Laboratories (UL):
      a. 547 - Thermal Protectors for Electric Motors.
      b. 674 - Electric Motors and Generators Used in Hazardous (Classified) Locations.

## 1.03 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. ODP: Open drip-proof enclosure.

E. TEFC: Totally enclosed, fan cooled enclosure.

F. TENV: Totally enclosed, nonventilated enclosure.

G. WPI: Open weather protected enclosure, Type I.

H. WPII: Open weather protected enclosure, Type II.

I. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

## 1.04 SUBMITTALS

A. Shop Drawings:
   1. Descriptive information.
   2. Nameplate data in accordance with NEMA MG 1.
   3. Additional Rating Information:
      a. Service factor.
      b. Locked rotor current.
      c. No load current.
      d. Safe stall time for motors 200 horsepower and larger.
      e. Multispeed load classification (e.g., variable torque).
      f. Adjustable frequency drive motor load classification (e.g., variable torque) and minimum allowable motor speed for that load classification.
   4. Enclosure type and mounting (e.g. horizontal, vertical).
   5. Dimensions and total weight.
   6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
   7. Bearing type.
   8. Bearing lubrication.
   9. Bearing life.
   10. Space heater voltage and watts.
   11. Description and rating of motor thermal protection.
   12. Motor sound power level in accordance with NEMA MG 1.
   13. Maximum brake horsepower required by the equipment driven by the motor.
   14. Description and rating of submersible motor moisture sensing system.

B. Quality Control Submittals:
   1. Factory test reports, certified.
   2. Manufacturer's Certificate of Proper Installation, 100 horsepower and larger.
   3. Operation and Maintenance Manual.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

A. General Electric.

B. Reliance.

C. MagneTek.

D. Siemens.

E. Balder.

F. U.S. Motors.

G. Westinghouse.

H. Toshiba.

### 2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, utilize a single supplier to provide a drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Frame assignments in accordance with NEMA MG 13.

E. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

F. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

G. Lifting lugs on all motors weighing 100 pounds or more.

H. Operating Conditions:
   1. Maximum ambient temperature not greater than 50 degrees C.
   2. Motors shall be suitable for operating conditions without any reduction being required in the nameplate rated horsepower or exceeding the rated temperature rise.
   3. Overspeed in either direction in accordance with NEMA MG 1.

## 2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specifications.

B. Constant Speed Applications: Brake horsepower of the driven equipment at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

C. Adjustable Frequency, Adjustable Speed Applications: Driven equipment brake horsepower at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

## 2.04 SERVICE FACTOR

A. 1.15 minimum at rated ambient temperature, unless otherwise indicated.

## 2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60-Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specifications:

| Size | Voltage | Phases |
|---|---|---|
| 1/2 hp and smaller | 115 | 1 |
| 3/4 hp through 400 hp | 460 | 3 |
| 450 hp and larger | 4,000 | 3 |

C. Suitable for full voltage starting.

D. One hundred horsepower and larger also suitable for reduced voltage starting with 65 or 80 percent voltage tap settings on reduced inrush motor starters.

E. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

## 2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 horsepower, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:
   1. Efficiency:
      a. Tested in accordance with NEMA MG 1, Paragraph 12.54.1.
      b. Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.
   2. Power Factor: Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.

## 2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower if motor horsepower not covered by NEMA MG 1 tables.

B. Safe stall time 15 seconds or greater.

## 2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Motors Rated Over 600 Volts: Sealed windings in accordance with NEMA MG 1.

C. Three-Phase and Integral Horsepower Motors, Unless Otherwise Indicated in Motor-Driven Equipment Specifications: Class F with Class B rise at nameplate horsepower and designated operating conditions, except EXP and DIP motors which must be Class B with Class B rise.

## 2.09 ENCLOSURES

A. All enclosures to conform to NEMA MG 1.

B. Unless otherwise noted, all motors shall be TEFC and shall furnish with a drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):
   1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class 1, Division 1, Group C and D hazardous locations.
   2. Drain holes with drain and breather fittings.
   3. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
   4. Thermostat leads to terminate in a terminal box separate from main terminal box.

D. Dust-Ignition-Proof (DIP):
   1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class II, Division 1, Group E, F, G.
   2. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
   3. Thermostat leads to terminate in a terminal box separate from main terminal box.

E. Submersible: In accordance with Article 2.16 SPECIAL MOTORS.

F. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Article 2.16 SPECIAL MOTORS.

## 2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for all motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1-11.06 and 20.62 and NFPA 70, Article 430:

| Voltage | Horsepower | Percentage |
|---|---|---|
| Below 600 | 15 thru 125 | 500 |
| Below 600 | 150 thru 300 | 275 |
| Below 600 | 350 thru 600 | 225 |
| Above 600 | All Sizes | 200 |

E. Terminal for connection of equipment grounding wire in each terminal box.

## 2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:
   1. 3/4 horsepower and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
   2. 1 Through 400 horsepower: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
   3. Above 400 horsepower: Regreasable antifriction bearings in labyrinth sealed end bells with removable grease relief plugs.
   4. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in AFBMA 9 and 11.

B. Vertical Motors:
   1. Thrust Bearings:
      a. Antifriction bearing.
      b. Manufacturer's standard lubrication 100 horsepower and larger.
      c. Oil lubricated 125 horsepower and larger.
      d. Minimum 50,000 hours L-10 bearing life.
   2. Guide Bearings:
      a. Manufacturer's standard bearing type.
      b. Manufacturer's standard lubrication 200 horsepower and larger.
      c. Oil lubricated 250 horsepower and larger.
      d. Minimum 100,000 hours L-1O bearing life.

C. Regreasable Antifriction Bearings:
   1. Readily accessible, grease injection fittings.
   2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:
   1. Oil reservoirs with sight level gauge.
   2. Oil fill and drain openings with opening plugs.
   3. Provisions for necessary oil circulation and cooling.

## 2.12 NOISE

A. Measured in accordance with IEEE 85 and NEMA MG 1.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

## 2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1-12.06.

## 2.14 EQUIPMENT FINISH

A. External Finish: Prime and finish coat manufacturer's standard. Field painting in accordance with Section 09_96_01 - High-Performance Coatings.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

## 2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen Over Air Openings: Stainless steel on motors with ODP, WPI, and WPII enclosures meeting requirements for Guarded Machine in NEMA MG 1.

B. Winding Thermal Protection:
   1. Thermostats:
      a. Motors for constant speed and adjustable speed application 30 through 75 horsepower.
      b. Bi-metal disk or rod type thermostats embedded in stator windings (normally closed contact).
      c. Automatic reset contacts rated 120 volts AC, 5 amps minimum, opening on excessive temperature. (Manual reset will be provided at motor controller.)
   2. Thermistors:
      a. Motors for constant speed and adjustable speed application 100 horsepower and larger.
      b. Thermistor embedded in each stator phase winding before winding dip and bake process.
      c. In intimate contact with winding conductors.
      d. Epoxy-potted, solid state thermistor control module mounted in NEMA 250, Type 4X box on motor by motor manufacturer.
      e. Individual thermistor circuits factory-wired to control module.

f. Control module rated for 120 volts AC power supply.
g. Control module automatically reset contact for external use rated 120 volts AC, 5 amps minimum, opening on abnormally high winding temperature. Manual reset will be provided at motor controller.

3. Motor Space Heaters: All motors 30 horsepower and larger except if otherwise noted, shall be furnished with 120V AC space heaters. The rating of the space heaters shall be determined in accordance with the motor manufacturer's standard for particular frame size and type. Coordinate the power requirements of the space heater with the manufacturer of motor starters or adjustable frequency drive for sizing of the control transformer. Space heater wire leads shall be brought out in the conduit box on the motor and clearly identified.

C. Nameplates:
1. Raised or stamped letters on stainless steel or aluminum.
2. Display all motor data required by NEMA MG 1-10.37 and NEMA MG 1-10.38 in addition to bearing numbers for both bearings.
3. Premium efficiency motor nameplates to also display NEMA nominal efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.

## 2.16 SPECIAL MOTORS

A. Requirements in this Article take precedence over conflicting features specified elsewhere in this section.

B. Chemical Industry, Severe-Duty (CISD-TEFC):
1. In accordance with IEEE 841.
2. TEFC in accordance with NEMA MG 1.
3. Suitable for indoor or outdoor installation in severe-duty applications including high humidity, chemical (corrosive), dirty, or salty atmospheres.
4. Motor Frame, End Shields, Terminal Box(es), and Fan Cover: Cast iron.
5. Ventilating Fan: Corrosion-resistant, nonsparking, external.
6. Drain and Breather Fittings: Stainless steel.
7. Nameplate: Stainless steel.
8. Gaskets between terminal box halves and terminal box and motor frame.
9. Extra slinger on rotor shaft to prevent moisture seepage along shaft into motor.
10. Double shielded bearings.
11. 125,000 hours minimum L-10 bearing life for direct-connected loads.
12. External Finish: Double-coated epoxy enamel.
13. Coated rotor and stator air gap surfaces.
14. Insulation System, Windings, and Connections:
a. Class F insulation, Class B rise or better at 1.0 service factor.
b. Multiple dips and bakes of nonhygroscopic polyester varnish.
15. Service Factor:
a. At 40 Degrees C Ambient: 1.15.
b. At 65 Degrees C Ambient: 1.00.
16. Safe Stall Time Without Injurious Heating: 20 seconds minimum.

C. Severe-Duty Explosion-Proof: Meet requirements for EXP enclosures and CISD-TEFC motors.

D. Severe-Duty, Dust-Ignition-Proof: Meet requirements for DIP enclosures and CISD-TEFC motors.

E. Multispeed: Meet requirements for speeds, number of windings, and load torque classification indicated in the motor-driven equipment specifications.

F. Submersible Pump Motors:
   1. Manufacturers:
      a. Reliance.
      b. Flygt.
   2. At 100 Percent Load:

| Horsepower | Guaranteed Minimum Efficiency | Guaranteed Minimum Power Factor |
|---|---|---|
| 5 thru 10 | 80 | 82 |
| 10.1 thru 50 | 85 | 82 |
| 50 1 thru 100 | 87 | 82 |
| Over 100 | 89 | 82 |

   3. Insulation System: Manufacturer's standard Class B or Class F.
   4. Motor capable of running dry continuously.
   5. Enclosure:
      a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
      b. Listed to meet UL 674 and NFPA 70 requirements for Class 1, Division 1, Group D hazardous atmosphere.
      c. Seals: Tandem mechanical.
   6. Bearing and Lubrication:
      a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
      b. Minimum 15,000 hours L-10 bearing life.
   7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.
   8. Winding Thermal Protection:
      a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
      b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
      c. Switch contacts rated at 5 amps, 120 volts AC.
   9. Motor Seal Failure Moisture Detection:
      a. Probes or sensors to detect moisture beyond seals.
      b. Probe or sensor monitoring module for mounting in motor controller, suitable for operation from 120-volt AC supply.
      c. Monitoring module with control power transformer, probe test switch and test light, and two independent 120-volt AC contacts, one opening and one closing when the flux of moisture is detected.
   10. Bearing Overtemperature Protection for Motors Larger than 100 Horsepower:
      a. Sensor on lower bearing housing monitoring bearing temperature.

b. Any monitoring relay necessary to provide 120-volt AC contact opening on bearing overtemperature.

11. Winding thermal protection, moisture detection, and bearing overtemperature specified above may be monitored by a single device providing two independent 120-volt AC contacts, one closing and one opening on malfunction.
12. Connecting Cables:
    a. One cable containing power, control, and grounding conductors.
    b. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
    c. Length: 30 feet minimum, coordinate proper length.
    d. UL 1 listed and sized in accordance with NFPA 70.

G. Inclined Motors:
1. Motors suitable for operation only in horizontal position not acceptable.
2. Bearings designed for thrust imposed by driven equipment and by motor rotor when motor is in inclined position.
3. Lubrication system designed to provide adequate bearing lubrication when motor is in inclined position.

H. Motors for Adjustable Frequency Drives (AFDs): These motors shall be specially designed inverter duty motors and comply with NEMA MG 1.31. Motor insulation shall withstand high voltages caused by fast rise time voltage pulses associated with PWM type inverters. Motor design shall take into account motor heating caused by harmonics in the drive output. Each motor for AFD application shall have a label certifying that the motor is suitable for inverter duty. Coordinate the motor full load current data with the drive manufacturer.

## 2.17 FACTORY TESTING

A. Tests:
1. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
2. Routine (production) tests on all motors in accordance with NEMA MG 1, plus no load power at rated voltage and polyphase, rated voltage measurement of locked rotor current. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency at 50, 75, and 100 percent of rated horsepower:
    a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraphs 12.54 and 12.57.
    b. For motors 500 horsepower and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
4. Power factor:
    a. Speed.
    b. Current at rated horsepower.
    c. kW input at rated horsepower.
    d. On motors of 100 horsepower and smaller, furnish a certified copy of a motor efficiency test report on an identical motor.

B. Test Report Forms:
   1. Routine Tests: IEEE 112, Form A-1.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts. Provide anchor bolts meeting manufacturer's recommendations and of sufficient size and number for the specified seismic conditions.

### 3.02 FIELD QUALITY CONTROL

A. Refer to Section 26_08_00 - Electrical Testing.

### 3.03 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative at site for installation assistance, inspection, equipment testing, and startup assistance for motors larger than 75 horsepower.

B. Manufacturer's Certificate of Proper Installation.

### 3.04 SUPPLEMENTS

A. Table supplement, following "END OF SECTION," is a part of this Specification.
   1. Table 1, Motor Performance Requirements.

END OF SECTION

| TABLE 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MOTOR PERFORMANCE REQUIREMENTS | | | | | | | | | |
| | | % Guar. Min. Full Load Efficiency | | | | % Guar. Min. Full Load Power Factor | | | |
| | | Horizontal | | Vertical | | Horizontal | | Vertical | |
| hp | Nominal Speed rpm | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC |
| 1 | 1,800 | 80.0 | 81.5 | | | Mfr.'s Std. | Mfr.'s Std. | | |
| | 1,200 | 78.5 | 79.3 | | | Mfr.'s Std. | Mfr.'s Std. | | |
| 1.5 | 3,600 | 79.3 | 81.5 | | | Mfr.'s Std. | Mfr.'s Std. | | |
| | 1,800 | 79.3 | 82.0 | | | Mfr.'s Std. | Mfr.'s Std. | | |
| | 1,200 | 82.5 | 84.0 | | 82.0 | Mfr.'s Std. | Mfr.'s Std. | | Mfr.'s Std. |
| 2 | 3,600 | 82.0 | 84.0 | | | Mfr.'s Std. | Mfr.'s Std. | | |
| | 1,800 | 81.5 | 83.7 | | | Mfr.'s Std. | Mfr.'s Std. | | |
| | 1,200 | 85.5 | 85.5 | 83.7 | 83.7 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 82.9 | 82.5 | 82.9 | 81.7 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| 3 | 3,600 | 82.0 | 84.0 | 82.0 | 82.0 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 84.8 | 86.5 | 84.8 | 84.8 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 87.5 | 88.1 | 87.5 | 86.6 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 84.1 | 82.9 | 84.1 | 82.9 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| 5 | 3,600 | 84.8 | 86.5 | 84.8 | 84.8 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 86.5 | 86.5 | 84.8 | 84.8 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 87.5 | 88.1 | 87.5 | 86.6 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 87.5 | 86.5 | 87.5 | 86.6 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |

| TABLE 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MOTOR PERFORMANCE REQUIREMENTS | | | | | | | | | |
| | | % Guar. Min. Full Load Efficiency | | | | % Guar. Min. Full Load Power Factor | | | |
| | | Horizontal | | Vertical | | Horizontal | | Vertical | |
| hp | Nominal Speed rpm | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC |
| 7.5 | 3,600 | 86.5 | 88.1 | 84.8 | 86.6 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 89.3 | 89.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 88.5 | 88.5 | 88.4 | 87.5 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 87.5 | 86.5 | 87.5 | 86.6 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| 10 | 3,600 | 89.3 | 89.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 89.3 | 89.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 89.5 | 89.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 89.3 | 88.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| 15 | 3,600 | 88.5 | 89.8 | 88.4 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 91.0 | 91.0 | 90.9 | 90.2 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 90.2 | 90.2 | 90.2 | 89.3 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 89.3 | 88.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| 20 | 3,600 | 91.0 | 90.6 | 90.9 | 89.3 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 91.7 | 91.7 | 91.7 | 90.9 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 91.0 | 90.6 | 90.2 | 89.3 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 90.2 | 89.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |

| TABLE 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MOTOR PERFORMANCE REQUIREMENTS | | | | | | | | | |
| | | % Guar. Min. Full Load Efficiency | | | | % Guar. Min. Full Load Power Factor | | | |
| | | Horizontal | | Vertical | | Horizontal | | Vertical | |
| hp | Nominal Speed rpm | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC |
| 25 | 3,600 | 91.7 | 91.0 | 91.7 | 90.2 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 92.4 | 92.4 | 92.4 | 91.7 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 91.7 | 91.0 | 90.9 | 89.3 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 90.2 | 89.5 | 89.3 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| 30 | 3,600 | 91.7 | 91.4 | 89.5 | 88.4 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,800 | 92.4 | 92.4 | 92.4 | 91.7 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 1,200 | 91.7 | 91.0 | 91.7 | 90.2 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| | 900 | 91.7 | 91.7 | 90.9 | 90.9 | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. | Mfr.'s Std. |
| 40 | 3,600 | 91.7 | 91.7 | 90.2 | 89.3 | 86.6 | 86.1 | 87.0 | 89.0 |
| | 1,800 | 93.6 | 93.0 | 92.8 | 91.7 | 78.2 | 78.2 | 83.0 | 84.5 |
| | 1,200 | 92.4 | 92.4 | 91.7 | 90.9 | 81.5 | 81.5 | 81.5 | 81.5 |
| | 900 | 91.7 | 91.0 | 90.9 | 90.2 | 70.0 | 70.5 | 70.0 | 70.5 |
| 50 | 3,600 | 92.0 | 92.0 | 90.2 | 89.3 | 85.1 | 86.7 | 89.0 | 89.0 |
| | 1,800 | 93.6 | 93.0 | 92.8 | 91.7 | 79.5 | 79.4 | 82.5 | 82.5 |
| | 1,200 | 92.4 | 92.4 | 91.7 | 90.9 | 81.5 | 81.5 | 81.5 | 81.5 |
| | 900 | 91.7 | 91.7 | 90.9 | 90.9 | 78.5 | 72.9 | 78.5 | 80.0 |

| TABLE 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MOTOR PERFORMANCE REQUIREMENTS | | | | | | | | | |
| | | % Guar. Min. Full Load Efficiency | | | | % Guar. Min. Full Load Power Factor | | | |
| | | Horizontal | | Vertical | | Horizontal | | Vertical | |
| hp | Nominal Speed rpm | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC |
| 60 | 3,600 | 92.7 | 93.0 | 91.7 | 90.9 | 85.8 | 88.3 | 87.5 | 89.0 |
| | 1,800 | 93.6 | 94.1 | 93.5 | 92.8 | 80.5 | 79.9 | 80.5 | 80.5 |
| | 1,200 | 93.0 | 93.0 | 92.8 | 91.7 | 81.5 | 81.5 | 81.5 | 81.5 |
| | 900 | 92.4 | 91.7 | 91.7 | 90.9 | 79.5 | 73.2 | 79.5 | 79.5 |
| 70 | 3,600 | 93.6 | 93.6 | 91.7 | 91.7 | 87.1 | 88.5 | 88.5 | 88.5 |
| | 1,800 | 94.5 | 94.5 | 93.5 | 93.5 | 81.0 | 81.5 | 81.0 | 81.5 |
| | 1,200 | 93.6 | 93.5 | 93.5 | 92.8 | 82.0 | 82.0 | 82.0 | 82.0 |
| | 900 | 92.8 | 92.4 | 92.8 | 91.7 | 80.5 | 74.5 | 80.5 | 81.0 |
| 100 | 3,600 | 93.6 | 93.3 | 91.7 | 90.7 | 87.0 | 88.2 | 87.0 | 88.5 |
| | 1,800 | 95.1 | 94.5 | 94.0 | 93.5 | 81.0 | 81.0 | 81.0 | 81.0 |
| | 1,200 | 93.6 | 93.6 | 92.8 | 92.8 | 82.1 | 81.7 | 85.5 | 85.5 |
| | 900 | 93.5 | 92.4 | 92.8 | 91.7 | 77.0 | 77.3 | 77.0 | 80.0 |
| 125 | 3,600 | 93.6 | 93.7 | 91.7 | 91.7 | 86.4 | 89.1 | 87.0 | 90.5 |
| | 1,800 | 94.5 | 94.7 | 93.5 | 92.8 | 85.4 | 85.5 | 87.5 | 86.0 |
| | 1,200 | 93.6 | 94.1 | 93.5 | 92.8 | 82.7 | 82.3 | 85.5 | 85.5 |
| | 900 | 93.5 | 93.0 | 92.8 | 92.4 | 78.5 | 78.5 | 78.5 | 78.5 |

| TABLE 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MOTOR PERFORMANCE REQUIREMENTS | | | | | | | | | |
| | | % Guar. Min. Full Load Efficiency | | | | % Guar. Min. Full Load Power Factor | | | |
| | | Horizontal | | Vertical | | Horizontal | | Vertical | |
| hp | Nominal Speed rpm | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC | Drip-Proof ODP | TEFC |
| 150 | 3,600 | 93.6 | 93.7 | 92.4 | 91.7 | 86.5 | 90.0 | 86.5 | 90.5 |
| | 1,800 | 95.0 | 95.2 | 94.5 | 94.0 | 82.5 | 85.0 | 84.5 | 85.0 |
| | 1,200 | 94.5 | 94.5 | 93.5 | 94.0 | 81.5 | 81.5 | 81.5 | 81.5 |
| | 900 | 93.5 | 93.0 | 92.8 | 92.4 | 78.0 | 78.5 | 78.0 | 78.5 |
| 200 | 3,,600 | 94.3 | 94.3 | 92.4 | 93.0 | 87.8 | 89.4 | 91.0 | 91.0 |
| | 1800 | 95.0 | 95.2 | 94.0 | 94.0 | 85.2 | 86.5 | 87.0 | 87.0 |
| | 1,200 | 94.5 | 94.5 | 93.5 | 93.5 | 79.0 | 82.5 | 79.0 | 82.5 |
| 250 | 3,600 | 94.3 | 94.7 | 91.7 | 92.4 | 85.0 | 86.5 | 85.0 | 96.5 |
| | 1,800 | 85.4 | 95.4 | 94.5 | 94.5 | 79.0 | 79.0 | 79.0 | 79.0 |
| | 1,200 | 95.0 | 94.5 | 94.5 | 93.5 | 82.0 | 82.0 | 82.0 | 82.0 |
| 300 | 3,600 | 93.7 | 94.3 | | | 89.8 | 89.9 | | |
| | 1,800 | 95.4 | 95.2 | 94.5 | 94.0 | 80.0 | 80.0 | 800 | 80.0 |
| | 1,200 | 93.7 | 93.7 | | | 84.5 | 90.1 | | |
| 350 | 3,600 | 94.3 | 94.7 | | | 89.4 | 85.9 | | |
| | 1,800 | 94.7 | 94.7 | | | 85.9 | 85.9 | | |

| TABLE 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **MOTOR PERFORMANCE REQUIREMENTS** | | | | | | | | | |
| | | **% Guar. Min. Full Load Efficiency** | | | | **% Guar. Min. Full Load Power Factor** | | | |
| | | **Horizontal** | | **Vertical** | | **Horizontal** | | **Vertical** | |
| **hp** | **Nominal Speed rpm** | **Drip-Proof ODP** | **TEFC** | **Drip-Proof ODP** | **TEFC** | **Drip-Proof ODP** | **TEFC** | **Drip-Proof ODP** | **TEFC** |
| 400 | 3,600 | 94.3 | | | | 88.4 | | | |
| | 1,800 | 9437 | | | | 86.8 | | | |
| 450 | 3,600 | 94.7 | | | | 89.1 | | | |
| 500 | 3,600 | 94.7 | | | | 88.3 | | | |

END OF SECTION

# SECTION 31_23_16

# EXCAVATION - EARTH AND ROCK

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes: Requirements for performing opencut excavations to the widths and depths necessary for constructing structures and pipelines, including excavation of any material necessary for any purpose pertinent to the construction of the Work.

### 1.02 DEFINITIONS

A. Earth: "Earth" includes all materials which, in the opinion of the Engineer, do not require blasting, barring, wedging or special impact tools for their removal from their original beds, and removal of which can be completed using standard excavating equipment. Specifically excluded are all ledge and bedrock and boulders or pieces of masonry larger than one cubic yard in volume.

B. Rock: "Rock" includes all materials which, in the opinion of the Engineer, require blasting, barring, wedging and/or special impact tools such as jack hammers, sledges, chisels, or similar devices specifically designed for use in cutting or breaking rock for removal from their original beds and which have compressive strengths in their natural undisturbed state in excess of 300 pounds per square inch. Boulders or masonry larger than one cubic yard in volume are classed as rock excavation.

### 1.03 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Engage the services of a Professional Engineer who is registered in the State of Florida to design all cofferdam and sheeting and bracing systems which the Contractor feels necessary for the execution of his work. Submit to the Engineer a signed statement that he has been employed by the Contractor to design all sheeting and bracing systems. After the systems have been installed, furnish to the Engineer an additional signed statement that the cofferdams and sheeting and bracing systems have been installed in accordance with his design.

### 1.04 SITE CONDITIONS

A. Geotechnical Investigation: A geotechnical investigation may have been prepared by the County and Engineer in preparing the Contract Documents.
   1. The geotechnical investigation report may be examined for whatever value it may be considered to be worth. However, this information is not guaranteed as to its accuracy or completeness.
   2. The geotechnical investigation report is not part of the Contract Documents.

B. Actual Conditions: Make any geotechnical investigations deemed necessary to determine actual site conditions.

C. Underground Utilities and Collier County Damage Prevention Policy:
   1. This policy has been put in place to avoid damage to Collier County underground utilities. A minimum distance of 5 feet horizontally and 18 inches vertically must be maintained away from Collier County utilities. Any and all variations from this order must be the Water or Wastewater Department.
   2. Before commencement of any excavation at road crossings or any boring or any drilling, the contractor shall mark the proposed run alignment with white paint or flags. Subsequent to placement of the white markings, the existing underground utilities in the area affected by the work must be marked by Sunshine One Call after proper notification to them by either calling 811 in Florida or toll free at 1-800-432-4770. Visit www.callsunshine.com for more information. Before commencing excavation for the work, potholing of all potential conflicts must be performed.
   3. All lines in conflict must be physically located by the contractor and verified by Collier County Locate Department personnel before performing work. Utilities under concrete or pavement may require soft dig vacuum locates which also is the contractor's responsibility to perform. All utilities will be field marked per Sunshine State One Call's statutes and guidelines. For line verification or any other information concerning locates, please call the Locate Department at 239- 252-5922 during normal business hours. For line verification or emergency locates after hours, call emergency numeric pager at 239-890-0809. In the event the potholing and/or vacuum soft dig does not locate the marked utility, work must be stopped and the affected utility owner contacted. Failure to comply with this policy and obtain required signature(s) may result in delay or denial of permit.
   4. The contractor must comply with all provisions of Florida Statute 556, the Underground Facility Damage Prevention and Safety Act.

D. Quality and Quantity: Make any other investigations and determinations necessary to determine the quality and quantities of earth and rock and the methods to be used to excavate these materials.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

### 3.01 GENERAL

A. Clearing: Clear open cut excavation sites of obstructions preparatory to excavation. Clearing as specified, includes removal and disposal of vegetation, trees, stumps, roots and bushes, except those specified to be protected during trench excavation.

B. Banks: Shore or slope banks to the angle of repose to prevent slides or cave-ins as specified.

C. Safety: Whenever an excavation site or trench is left unattended by the Contractor or when an area is not within 100 feet of observation by the Contractor, the excavation site or trench shall be filled and/or, at the County's Manager or designee discretion, protected by other means to prevent accidental or unauthorized entry. Include barricades and other protection devices requested by the Engineer or County Manager or designee, including temporary fencing, snow fencing, or temporary "structure" tape. Such safety items shall not relieve the Contractor of any site safety requirements or liabilities established by Federal, State and local laws and agencies, including OSHA, but is intended as additional safety measures to protect the general public.

D. Hazardous Materials: If encountered, take care of hazardous materials not specifically shown or noted in accordance with the project documents and specifications.

E. During excavation and any site work, take storm water pollution prevention measures to ensure that water quality criteria are not violated in the receiving water body and all state and local regulatory requirements are met.

## 3.02 STRUCTURE EXCAVATION

A. Excavation Size: Provide excavations of sufficient size and only of sufficient size to permit the Work to be economically and properly constructed in the manner and of the size specified.

B. Excavation Shape: Shape and dimension the bottom of the excavation in earth or rock to the shape and dimensions of the underside of the structure or drainage blanket wherever the nature of the excavated material permits.

C. Compaction: Before placing foundation slabs, footings or backfill, proof roll the bottom of the excavations to detect soft spots.
   1. For accessible areas, proof roll with a 10-wheel tandem axle dump truck loaded to at least 15 tons or similarly loaded construction equipment.
   2. For small areas, proof roll with a smooth-faced steel roller filled with water or sand, or compact with a mechanical tamper.
   3. Make one complete coverage, with overlap, of the area.
   4. Over excavate soft zones and replace with compacted select fill.

## 3.03 TRENCH EXCAVATION

A. Preparation: Properly brace and protect trees, shrubs, poles and other structures which are to be preserved. Unless shown or specified otherwise, preserve all trees and large shrubs. Hold damage to the root structure to a minimum. Small shrubs may be preserved or replaced with equivalent specimens.

B. Adequate Space: Keep the width of trenches to a minimum, however provide adequate space for workers to place, joint and backfill the pipe properly.
   1. The minimum width of the trench shall be equal to at least 3.5 feet or the outside diameter of the pipe at the joint plus 8-inches for unsheeted trench or 12 inches for sheeted trench, whichever is greater. Conform the trench walls to OSHA Regulations.

2. In sheeted trenches, measure the clear width of the trench at the level of the top of the pipe to the inside of the sheeting.

C. Depth:
   1. Excavate trenches to a minimum depth of 8 inches, but not more than 12 inches, below the bottom of the pipe so that bedding material can be placed in the bottom of the trench and shaped to provide a continuous, firm bearing for pipe barrels and bells.
   2. Standard trench grade shall be defined as the bottom surface of the utility to be constructed or placed within the trench. Trench grade for utilities in rock or other non-cushioning material shall be defined as additional undercuts backfilled with crushed stone compacted in 6-inch lifts, below the standard 8-inches minimum trench undercut. Backfill excavation below trench grade not ordered in writing by the Engineer with acceptable Class I, II or III embedment material to trench grade and compact to density equal to native soil.

D. Unstable or Unsuitable Materials: If unstable or unsuitable material is exposed at the level of the bottom of the trench excavation, excavate the material in accordance with the subsection headed "Authorized Additional Excavation".
   1. Remove material for the full width of the trench and to the depth required to reach suitable foundation material.
   2. When in the judgment of the Engineer the unstable or unsuitable material extends to an excessive depth, the Engineer may advise, in writing, the need for stabilization of the trench bottom with additional select fill material, crushed stone, washed shell, gravel mat or the need to provide firm support for the pipe or electrical duct by other suitable methods.
   3. Crushed stone, washed shell and gravel shall be as specified.
   4. Payment for such trench stabilization will be made under the appropriate Contract Items or where no such items exist, as a change in the Work.

E. Length of Excavation: Keep the open excavated trench preceding the pipe laying operation and the unfilled trench, with pipe in place, to a minimum length which causes the least disturbance. Provide ladders for a means of exit from the trench as required by applicable safety and health regulations.

F. Excavated Material: Neatly deposit excavated material to be used for backfill at the sides of the trenches where space is available. Where stockpiling of excavated material is required, obtain the sites to be used and maintain operations to provide for natural drainage and not present an unsightly appearance.

G. Water: Allow no water to rise in the trench excavation until sufficient backfill has been placed to prevent pipe flotation. Provide trench dewatering as specified.

## 3.04 EXCAVATION FOR JACKING AND AUGERING

A. Jacking and Augering Requirements: Allow adequate length in jacking pits to provide room for the jacking frame, the jacking head, the reaction blocks, the jacks, auger rig, and the jacking pipe. Provide sufficient pit width to allow ample working space on each side of the jacking frame. Allow sufficient pit depth such that the invert of the pipe, when placed on the guide frame, will be at the elevation desired for the completed line. Tightly sheet the pit and keep it dry at all times.

## 3.05 ROCK EXCAVATION

A. Rock Excavation: Excavate rock within the boundary lines and grades as shown, specified or required.
   1. Rock removed from the excavation becomes the property of the Contractor. Transport and dispose of excavated rock at an offsite disposal location. Obtain the offsite disposal location.
   2. Remove all shattered rock and loose pieces.

B. Structure Depths: For cast-in-place structures, excavate the rock only to the bottom of the structure, foundation slab, or drainage blanket.

C. Trench Width: Maintain a minimum clear width of the trench at the level of the top of the pipe of the outside diameter of the pipe barrel plus 2 feet, unless otherwise approved.

D. Trench Depth: For trench excavation, in which pipelines are to be placed, excavate the rock to a minimum depth of 8 inches below the bottom of the pipe or duct encasement. Provide a cushion of sand or suitable crushed rock. Refill the excavated space with pipe bedding material in as specified. Include placing, compacting and shaping pipe bedding material in the appropriate Contract Items.

E. Over-excavated Space: Refill the excavated space in rock below structures, pipelines, conduits and manholes, which exceeds the specified depths with 2,500 pound-per-square-inch concrete, crushed stone, washed shell, or other material as directed. Include refilling of over-excavated space in rock as part of the rock excavation.

F. Other Requirements: Follow, where applicable, the requirements of the subsections on "Trench Excavation" and "Structure Excavation".

G. Payment: Rock excavation, including placing, compacting and shaping of the select fill material, will be paid for under the appropriate Contract Items.

## 3.06 FINISHED EXCAVATION

A. Finish: Provide a reasonably smooth finished surface for all excavations, which is uniformly compacted and free from irregular surface changes.

B. Finish Methods: Provide a degree of finish that is ordinarily obtainable from blade-grad operations as specified.

## 3.07 PROTECTION

A. Traffic and Erosion: Protect newly graded areas from traffic and from erosion.

B. Repair: Repair any settlement or washing away that may occur from any cause, prior to acceptance. Re-establish grades to the required elevations and slopes.

C. It shall be the Contractor's responsibility to acquaint himself with all existing conditions and to locate all structures and utilities along the proposed utility alignment in order to avoid conflicts. Where actual conflicts are unavoidable, coordinate work with the facility owner and perform work so as to cause as little interference as possible with the service rendered by the facility disturbed as specified. Repair and/or replace facilities or structures damaged in the prosecution of the work immediately, in conformance with current standard practices of the industry, or according to the direction of the owner of such facility, at the Contractor's expense.

D. Other Requirements: Conduct all Work in accordance with the environmental protection requirements specified in Division 1.

## 3.08 AUTHORIZED ADDITIONAL EXCAVATION

A. Additional Excavation: Carry the excavation to such additional depth and width as authorized in writing, for the following reasons:
   1. In case the materials encountered at the elevations shown are not suitable.
   2. In case it is found desirable or necessary to go to an additional depth, or to an additional depth and width.

B. Refill Materials: Refill such excavated space with either authorized 2,500 pound-per-square-inch concrete or compacted select fill material, as specified.

C. Compaction: Compact fill materials to avoid future settlement. As a minimum, backfill layers shall not exceed 6 inches in thickness for the full trench width and compaction shall equal 95 percent of maximum density, or 98 percent if under paved area of roadway, as determined by using ASTM D 1557. Perform compaction density tests at all such backfill areas with spacing not to exceed 100 feet apart and on each 6-inch compacted layer.

D. Payment: Additional earth excavations so authorized and concrete or select fill materials authorized for filling such additional excavation and compaction of select fill materials will be paid for under the appropriate Contract Items or where no such items exist, as a change in the Work.

## 3.09 UNAUTHORIZED EXCAVATION

A. Stability: Refill any excavation carried beyond or below the lines and grades shown, except as specified in the subsection headed "Authorized Additional Excavation", with such material and in such manner as may be approved in order to provide for the stability of the various structures.

B. Refill Materials: Refill spaces beneath all manholes, structures, pipelines, or conduits excavated without authority with 2,500 pound-per-square-inch concrete or compacted select fill material, as approved.

C. Payment: Refill for unauthorized excavation will not be measured and no payment will be made therefor.

## 3.10 SEGREGATION STORAGE AND DISPOSAL OF MATERIAL

A. Stockpiling Suitable Materials: Stockpile topsoil suitable for final grading and landscaping and excavated material suitable for backfilling or embankments separately on the site in approved locations.

B. Stockpile Locations: Store excavated and other material a sufficient distance away from the edge of any excavation to prevent its falling or sliding back into the excavation and to prevent collapse of the wall of the excavation. Provide not less than 2 feet clear space between the top of any stockpile and other material and the edge of any excavation.

C. Excess Materials: Be responsible for transport and disposal of surplus excavated material and excavated material unsuitable for backfilling or embankments at an offsite disposal location secured by the Contractor.

## 3.11 REMOVAL OF WATER

A. Water Removal: At all times during the excavation period and until completion and acceptance of the Work at final inspection, provide ample means and equipment with which to remove promptly and dispose of properly all water entering any excavation or other parts of the Work.

B. Dry Excavations: Keep the excavation dry as specified.

C. Water Contact: Allow no water to rise over or come in contact with masonry and concrete until the concrete and mortar have attained a set and, in any event, not sooner than 12 hours after placing the masonry or concrete.

D. Discharge of Water: Dispose of water pumped or drained from the Work in a safe and suitable manner without damage to adjacent property or streets or to other work under construction.

E. Protection: Provide adequate protection for water discharged onto streets. Protect the street surface at the point of discharge.

F. Sanitary Sewers: Discharge no water into sanitary sewers.

G. Storm Sewers: Discharge no water containing settleable solids into storm sewers.

H. Repair: Promptly repair any and all damage caused by dewatering the Work.

END OF SECTION

# SECTION 31_23_19

# GROUNDWATER CONTROL FOR OPEN CUT EXCAVATION

## PART 1 GENERAL

### 1.01 DESCRIPTION OF REQUIREMENTS

A. This section provides for furnishing all permits, labor, materials, equipment, power and incidentals for performing all operations necessary to dewater, depressurize, drain and maintain excavations as described herein and as necessary for installation of pipeline and appurtenances. Included are installing, maintaining, operating and removing dewatering systems and other approved devices for the control of surface and groundwater during the construction of pipelines and appurtenances, open cut excavations, directional drilling. Included also are protecting work against rising waters and repair of any resulting damage.

### 1.02 CONTRACTOR'S RESPONSIBILITY

A. It is the sole responsibility of the Contractor to identify groundwater conditions and to provide any and all labor, material, equipment, techniques and methods to lower, control and handle the groundwater as necessary for his construction methods and to monitor the effectiveness of this installed system and its effect on adjacent facilities.

B. Operate, maintain and modify the system(s) as required to conform to these Specifications. Upon completion of the Construction, remove the system(s). The development, drilling and abandonment of all wells used in the dewatering system shall comply with regulations of the Florida Department of Environmental Protection and the governing Water Management District.

C. Assume sole responsibility for dewatering systems and for all loss or damage resulting from partial or complete failure of protective measures and any settlement or resultant damage caused by the dewatering operation.

### 1.03 PLANS AND OTHER DATA TO BE SUBMITTED

A. Prior to commencement of work, submit complete drawings, details and layouts showing the proposed dewatering plans in sufficient detail (i.e., general arrangements, procedures to be used, etc.) so as to allow the Engineer to evaluate the proposed dewatering systems. Include the following, as required by the Contractor's proposed operation:
   1. Names of equipment suppliers.
   2. Names of installation subcontractors.
   3. Plan for dewatering at access shafts and control of surface drainage.
   4. Plan for dewatering for cut-and-cover excavations, or otherwise controlling groundwater.
   5. Eductor system layout and details.
   6. Deep well locations and details.

7. Well point system layout and details.
8. Installation reports for eductors, deep wells and well points.
9. Water level readings from piezometers or observation wells, and method of maintenance.
10. As part of his request for approval of a dewatering system, demonstrate the adequacy of the proposed system and well point filler sand by means of a test installation.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

### 3.01 DEWATERING EXCAVATIONS

A. Obtain all permits necessary for dewatering operations and file a copy of all such permits with the County Manager or designee and Engineer.

B. Furnish, install, operate and maintain all necessary equipment for dewatering the various parts of the Work and for maintaining free of water the excavations and such other parts of the Work as required for Construction operations. Dewatering system should provide for continuous operation including nights, weekends, holidays, etc. Provide appropriate backup if electrical power is primary energy source for dewatering system.

C. Continue dewatering in all required areas, until the involved work is completed, including the placing and compaction of backfill materials.

D. Provide a uniform diameter for each pipe drain run constructed for dewatering. Remove the pipe drain when it has served its purpose. If removal of the pipe is impractical, provide grout connections at 50-foot intervals, and fill the pipe with clay grout or cement and sand grout when the pipe has served its purpose.

### 3.02 DEWATERING TRENCH

A. Dewatering Excavation Plan: Develop an excavation dewatering plan that considers site ground and groundwater conditions, the type and arrangement of the equipment to be used and the proper method of groundwater disposal. Prepare the dewatering plan before beginning excavations below groundwater. Maintain one copy of the dewatering plan at the project site to be available for inspection while all dewatering operations are underway.

B. Do not lay any pipeline in a trench in the presence of water. Remove all water from the trench sufficiently ahead of the pipeline placing operation. The Engineer shall have full and final authority to require dewatering of the trench to ensure a dry, firm bed on which to place the pipeline. As a minimum, maintain water levels at least 6 inches below the bottom of the trench. Continue to dewater trench until trench backfilling operations have been completed.
   1. If a dry trench bottom has not been obtained with usual methods of trench dewatering, then the order to excavate below grade and place sufficient select fill material, crushed stone, or 2,500 pound-per-square-inch concrete over the trench bottom may be given.
   2. If all efforts fail to obtain a stable dry trench bottom, and it is determined that the trench bottom is unsuitable for pipe foundation, present an alternate system for stabilization to the Engineer of Record for approval by the County Manager or designee on a case-by-case basis.

C. Removal of water may be accomplished by pumping in connection with well point installation as the particular situation may warrant.

D. If the soils encountered at the trench grade are suitable for the passage of water, without destroying the sides or utility foundation of the trench, sumps may be provided at intervals at the side of the main trench excavation. Use pumps to lower the water level by taking their suction from said sumps.

## 3.03 REQUIREMENTS FOR EDUCTOR, WELL POINTS OR DEEP WELLS

A. Eductor, well points or deep wells, where used, must be furnished, installed and operated by a reputable Contractor regularly engaged in this business, and approved.

## 3.04 DURATION OF DRAINAGE

A. In areas where concrete is to be placed, carry out the foundation drainage so that the required lowering of the water table will be effected prior to placing reinforcing steel. Keep foundation beds free from water to the same levels for 3 days after placing concrete.

## 3.05 PROTECTION OF STRUCTURES

A. Provide adequate protection for all structures to avoid damage to concrete.

B. Operate construction equipment over completed concrete slabs or structures only with approval. Rubber tire equipment heavier than 5 tons and crawlers heavier than 7 tons will require adequate load spreading by sand fill or other means.

## 3.06 DISCHARGE OF WATER

A. Do not discharge pumped drainage water into the sanitary sewer system or inhibit pedestrian or vehicular traffic with the groundwater control system.

B. Discharge pumped drainage water into the storm sewer system or drainage ditch by direct means (i.e., discharge hose to inlet, burying header, etc.). Monitor the discharged water to determine that soil particles are not being removed.

C. Conform all discharge to current South Florida Water Management District and Collier County Department of Stormwater Management rules, regulations, procedures and regulatory permits and if discharged into receiving waters, shall not exceed 29 NTUs above background.

## 3.07 REPAIR OF DAMAGE

A. Assume full responsibility for all loss and damage due to flooding, rising water or seepage resulting from dewatering operations in any part of the work. Repair any damage to partially completed work from these or other causes, including the removal of slides, repair of foundation beds and performance of any other work necessitated by lack of adequate dewatering or drainage facilities.

END OF SECTION

# SECTION 31_23_23

# BACKFILLING

## PART 1 GENERAL

### 1.01 SUMMARY

A. General Requirements: Backfill all excavation to the original surface of the ground or to such other grades as may be shown or required. For areas to be covered by topsoil, leave or stop backfill 12 inches below the finished grade. Obtain approval for the time elapsing before backfilling against masonry structures. Remove from all backfill, any compressible, putrescible, or destructible rubbish and refuse and all lumber and braces from the excavated space before backfilling is started. Leave sheeting and bracing in place or remove as the work progresses.

B. Equipment Limitations: Do not permit construction equipment used to backfill to travel against and over cast-in-place concrete structures until the specified concrete strength has been obtained, as verified by concrete test cylinders. In special cases where conditions warrant, the above restriction may be modified providing the concrete has gained sufficient strength, as determined from test cylinders, to satisfy design requirements for the removal of forms and the application of load.

### 1.02 REFERENCES

A. Codes and standards referred to in this Section are:
   1. ASTM D 1557-Standard Test Methods for Moisture-Density Relations of Soil and Soil-Aggregate Mixtures Using 10 lb Rammer and 18 in Drop

## PART 2 PRODUCTS

### 2.01 BACKFILL MATERIAL - GENERAL

A. General: Refer to Utilities Standards and Procedures Ordinance Section 9.1.2 for laying and backfilling requirements. Backfill with sound materials, free from waste, organic matter, rubbish, boggy or other unsuitable materials. Acceptable backfill shall not contain rocks or stones larger than 2 inches in size.

B. General Materials Requirements: Conform materials used for backfilling to the requirements specified. Follow common fill requirements whenever drainage or select fill is not specified. Determine and obtain the approval of the appropriate test method where more than one compaction test method is specified.

C. Classification of Approved Embedment Materials: Embedment materials listed here include a number of processed materials plus the soil types defined according to the Unified Soil Classification System (USCS) in ASTM D2487. These materials are grouped into 5 broad categories according to their suitability for this application.

1. Class I: Angular, 0.25 inch to 1.5 inch (6 to 40 mm) graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed shells and crushed stone. (Note: The size range and resulting high void ratio of Class I material makes it suitable for use to dewater trenches during pipe installation. This permeable characteristic dictates that its use be limited to locations where pipe support will not be lost by migration of fine-grained natural material from the trench walls and bottom or migration of other embedment materials into the Class I material. When such migration is possible, the material's minimum size range should be reduced to finer than 0.25 inch (6 mm) and the gradation properly designed to limit the size of the voids. An alternative to modifying the gradation is to use a geotextile fabric as a barrier to migration to fines.)
2. Class II: Coarse sands and gravels with maximum particle size of 1.5 inches (40 mm), including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil Types GW, GP, SW and SP are included in this class. (Note: Sands and gravels, which are clean or borderline between clean and with fines, should be included. Coarse-grained soils with less than 12 percent, but more than 5 percent fines are neglected in ASTM D2487 and the USCS, but should be included. The gradation of Class II material influences its density and pipe support strength when loosely placed. The gradation of Class II material may be critical to the pipe support and stability of the foundation and embedment, if the material is imported and is not native to the trench excavation. A gradation other than well graded, such as uniformly graded or gap graded, may permit loss of support by migration into void spaces of a finer grained natural material from the trench wall and bottom. An alternative to modifying the gradation is to use a geotextile fabric as a barrier to migration of fines.)
3. Class III: Fine sand and clayey (clay filled) gravels, including fine sands, sand-clay mixtures and gravel-clay mixtures. Soil Types GM, GC, SM and SC are included in this class.
4. Class IV: Silt, silty clays and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types MH, ML, CH and CL are included in this class. (Note: Use caution in the design and selection of the degree and method of compaction for Class IV soils because of the difficulty in properly controlling the moisture content under field conditions. Some Class IV soils with medium to high plasticity and with liquid limits greater than 50 percent (CH, MH, CH-MH) exhibit reduced strength when wet and should only be used for bedding, haunching and initial backfill in arid locations where the pipe embedment will not be saturated by groundwater, rainfall or exfiltration from the pipe. Class IV soils with low to medium plasticity and with liquid limits lower than 50 percent (CL, ML, CL-ML) also require careful consideration in design and installation to control moisture content, but need not be restricted in use to arid locations.)

5. Class V: This class includes the organic soils OL, OH and PT as well as soils containing frozen earth, debris, rocks larger than 1.5 inches (40 mm) in diameter and other foreign materials. Do not use these materials for bedding, haunching or backfill.

## 2.02 SELECT FILL

A. Materials for Select Fill: Use clean gravel, crushed stone, washed shell, or other granular or similar material as approved which can be readily and thoroughly compacted to 95 percent of the maximum dry density obtainable by ASTM D1557.
   1. Allowed Materials: Grade select fill between the following limits:

| U.S. Standard Sieve | Percent Passing By Weight |
|---|---|
| 2 inch | 100 |
| 1-1/2 inch | 90-100 |
| 1 inch | 75-95 |
| 1/2 inch | 45-70 |
| #4 | 25-50 |
| #10 | 15-40 |
| #200 | 5-15 |

   2. Unallowed Materials: Very fine sand, uniformly graded sands and gravels, sand and silt, soft earth, or other materials that have a tendency to flow under pressure when wet are unacceptable as select fill.

## 2.03 COMMON FILL

A. Materials for Common Fill: Material from on-site excavation may be used as common fill provided that it can be readily compacted to 90 percent of the maximum dry density obtainable by ASTM D 1557, and does not contain unsuitable material. Select fill may be used as common fill at no change in the Contract Price.

B. Granular Materials On-Site: Granular on-site material, which is fairly well graded between the following limits may be used as granular common fill:

| U.S. Standard Sieve | Percent Passing By Weight |
|---|---|
| 2 inch | 100 |
| #10 | 50-100 |
| #60 | 20-90 |
| #200 | 0-20 |

C. Cohesive Materials On-Site: Cohesive site material may be used as common fill.
   1. The gradation requirements do not apply to cohesive common fill.
   2. Use material having a liquid limit less than or equal to 40 and a plasticity index less than or equal to 20.

D. Material Approval: All material used as common fill is subject to approval. If there is insufficient on-site material, import whatever additional off-site material is required which conforms to the specifications and at no additional cost.

## 2.04 UTILITY PIPE BEDDING

A. Gradation for Small Piping: For pipe 18 inches or less in diameter, use pipe bedding of material 90 percent of which will be retained on a No. 8 sieve and 100 percent of which will pass a 1/2-inch sieve and be well graded between those limits.

B. Gradation for Large Piping: For pipe larger than 18 inches in diameter, use the same pipe bedding material as specified for smaller pipe or use a similar well graded material 90 percent of which will be retained on a No. 8 sieve and 100 percent of which will pass a 1-inch sieve.

C. Provide a minimum of 6 inches bedding material under all gravity sewer piping. In areas where poor soil conditions or rock exist, provide a minimum of 6 inches of pipe bedding material under water or force main pressure pipe.

# PART 3 EXECUTION

## 3.01 PIPE BEDDING AND INITIAL BACKFILL

A. Placement: Place backfill for initial pipe backfill from top of bedding to 1 foot over top of pipes in uniform layers not greater than 8 inches in loose thickness. Tamp under pipe haunches and thoroughly compact in place the backfill with suitable mechanical or pneumatic tools to not less than 98 percent of the maximum dry density as determined by ASTM D 1557.

B. Foundation Bedding: Place bedding, to a depth specified by the County Manager or designee, as a foundation in wet, yielding or mucky locations. Construct foundation bedding by removal of the wet, yielding or mucky material and replacement with sufficient Class I material to correct soil instability.

C. Stone Placement: Do not place large stone fragments in the pipe bedding or backfill within 2 feet over or around pipelines, or nearer than 2 feet at any point from any casing pipe, conduit or concrete wall.

D. Machine Compaction: Machine Compaction of initial backfill is prohibited unless adequate cover as deemed by the County Manager or designee is provided. In no case shall adequate cover be less than 12 inches.

## 3.02 PIPE BEDDING AND INITIAL BACKFILL

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D. Machine Compaction: Machine Compaction of initial backfill is prohibited unless adequate cover as deemed by the County Manager or designee is provided. In no case shall adequate cover be less than 12 inches.

E. Unallowed Materials: Pipe bedding containing very fine sand, uniformly graded sands and gravels, sand and silt, soft earth, or other materials that have a tendency to flow under pressure when wet is unacceptable.

## 3.03 TRENCH BACKFILL

A. General: Backfill trenches from 1 foot over the top of the pipe, from the top of electrical duct bedding or as shown to the bottom of pavement base course, subgrade for lawns or lawn replacement, to the top of the existing ground surface or to such other grades as may be shown or required.

B. Materials: All backfill material shall be acceptable dry materials, and shall be free from cinders, ashes, refuse, vegetable or organic material, boulders, rocks, or stones, or other deleterious material which in the opinion of the County Manager or designee is unsuitable.

C. Depth of Placement - Place trench backfill in uniform layers not greater than 12 inches in loose thickness and that can be thoroughly compacted in place using suitable mechanical or pneumatic equipment to not less than 98 percent of the maximum dry density as determined by ASTM D 1557.

D. Depth of Placement - Undeveloped Areas: In nondeveloped areas and where select fill material or hand-placed backfill are not specified or required, place suitable job-excavated material or other approved backfill in lifts not exceeding 12 inches in loose thickness. Lifts of greater thickness may be permitted by the County Manager or designee if the Contractor demonstrates compliance with required densities. When the trench is full, consolidate the backfill by jetting, spading, or tamping to ensure complete filling of the excavation. Mound the top of the trench approximately 12 inches to allow for consolidation of backfill.

E. Compaction: Compact backfill as a percentage of the maximum density at optimum moisture content as determined by the standard proctor test, ASTM D698 as demonstrated in the following table:

| Area | (Mod.) ASTM D1557 |
|---|---|
| Around and 1' (Min) above top of pipe | 98 |
| Remaining Trench | 98 |
| Pavement Sub-Grade and Shoulders (Last 3' of Fill) | 98 |
| Base Material and Pavement | 98 |
| Adjacent to Structures (Areas not Paved) | 98 |
| Under Structures | 98 |
| Sub-Base | 98 |

F. Density Tests: Density tests will be made at the request of the County Manager or designee. Deficiencies will be corrected at the expense of the Contractor.

G. Dropping of Material on Work: Do trench backfilling work in such a way as to prevent dropping material directly on top of any conduit or pipe through any great vertical distance.

H. Distribution of Large Materials: Break lumps up and distribute any stones, pieces of crushed rock or lumps which cannot be readily broken up, throughout the mass so that all interstices are solidly filled with fine material.

## 3.04 STRUCTURE BACKFILL

A. Use crushed stone underneath all structures, and adjacent to structures where pipes, connections and structural foundations are to be located within this fill. Use crushed stone beneath all pavements, walkways, and railroad tracks, and extend to the bottom of pavement base course or ballast.
   1. Place backfill in uniform layers not greater than 8 inches in loose thickness and thoroughly compact in place with suitable approved mechanical or pneumatic equipment.
   2. Compact backfill to not less than 95 percent of the maximum dry density as determined by ASTM D 1557.

B. Use of Common Fill: Use common granular fill adjacent to structures in all areas not specified above. Select fill may be used in place of common granular fill at no additional cost.
   1. Extend such backfill from the bottom of the excavation or top of bedding to the bottom of subgrade for lawns or lawn replacement, the top of previously existing ground surface or to such other grades as may be shown or required.
   2. Place backfill in uniform layers not greater than 8 inches in loose thickness and thoroughly compact in place with suitable equipment, as specified above.

3. Compact backfill to not less than 90 percent of the maximum dry density as determined by ASTM D 1557.

## 3.05 COMPACTION EQUIPMENT

A. Equipment and Methods: Carry out all compaction with suitable approved equipment and methods.
   1. Compact clay and other cohesive material with sheep's-foot rollers or similar equipment where practicable. Use handheld pneumatic tampers elsewhere for compaction of cohesive fill material.
   2. Compact low cohesive soils with pneumatic-tire rollers or large vibratory equipment where practicable. Use small vibratory equipment elsewhere for compaction of cohesionless fill material.
   3. Do not use heavy compaction equipment over pipelines or other structures, unless the depth of fill is sufficient to adequately distribute the load.

## 3.06 FINISH GRADING

A. Final Contours: Perform finish grading in accordance with the completed contour elevations and grades shown and blend into conformation with remaining natural ground surfaces.
   1. Leave all finished grading surfaces smooth and firm to drain.
   2. Bring finish grades to elevations within plus or minus 0.10 foot of elevations or contours shown.

B. Surface Drainage: Perform grading outside of building or structure lines in a manner to prevent accumulation of water within the area. Where necessary or where shown, extend finish grading to ensure that water will be carried to drainage ditches, and the site area left smooth and free from depressions holding water.

## 3.07 RESPONSIBILITY FOR AFTERSETTLEMENT

A. Aftersettlement Responsibility: Take responsibility for correcting any depression which may develop in backfilled areas from settlement within one year after the work is fully completed. Provide, as needed, backfill material, pavement base replacement, permanent pavement, sidewalk, curb and driveway repair or replacement, and lawn replacement, and perform the necessary reconditioning and restoration work to bring such depressed areas to proper grade as approved.

## 3.08 INSPECTION AND TESTING OF BACKFILLING

A. Sampling and Testing: Provide sampling, testing, and laboratory methods in accordance with the appropriate ASTM Standard Specification. Subject all backfill to these tests.

B. Correction of Work: Correct any areas of unsatisfactory compaction by removal and replacement, or by scarifying, aerating or sprinkling as needed and recompaction in place prior to placement of a new lift.

C. Testing Schedule:
    1. Compaction Schedule.
    2. Optimum Moisture Content (Proctor Test).

END OF SECTION

## SECTION 31_34_07

## LOW DENSITY CELLULAR CONCRETE FILL

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes: Low density cellular concrete fill (LDCCF).

## 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 523.1R - Guide for Cast-in-Place Low-Density Cellular Concrete.

B. ASTM International (ASTM):
   1. C495 - Standard Test Method for Compressive Strength of Lightweight Insulating Concrete.
   2. C567 - Standard Test Method for Determining Density of Structural Lightweight Concrete.
   3. C796 - Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam.
   4. C869 - Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete.

## 1.03 SUBMITTALS

A. Mix design.

B. Cellular concrete applicator qualifications.

C. Test reports.

## 1.04 QUALITY ASSURANCE

A. Cellular concrete applicator qualifications:
   1. Cellular concrete applicator shall be approved by the manufacturer of the cellular concrete.
   2. Cellular concrete applicator shall be regularly engaged in the placement of cellular concrete including completion of minimum of 40,000 cubic yards in past 5 years.
      a. Cellular concrete applicator shall furnish a list of all cellular concrete projects completed in last 5 years.
      b. List shall contain the names, addresses, and telephone numbers of the references for these projects.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

A. Manufacturers: One of the following or equal:
   1. Elastizell Corp. of America, Elastizell EF.
   2. Aerix Industries, Aerlite.

### 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Cellular concrete properties:
      a. Cellular concrete for the existing Meter Vault No. 2, with maximum cast density of 30 pounds per cubic foot, and with minimum compressive strength of 40 pounds per square inch.
      b. Cellular concrete for the existing manhole, with maximum cast density of 30 pounds per cubic foot, and with minimum compressive strength of 40 pounds per square inch.
   2. Provide cellular concrete work conforming with best standard practices, in accordance with ACI 523.1R, and recommenced practices.

### 2.03 MATERIALS

A. Cellular concrete components:
   1. Type II low alkali portland cement.
   2. Water as specified in Section 03_30_01 - Concrete Work.
   3. Foaming agent: In accordance with ASTM C869 when tested in accordance with ASTM C796.

### 2.04 PRE-PRODUCTION TESTING

A. Take 2 sets comprising 4 cylinders for each proposed mix and perform compressive strength tests on samples at 28 calendar days in accordance with ASTM C495.

### 2.05 EQUIPMENT

A. General:
   1. Furnish equipment of sufficient size to batch and pump the required volume of low-density cellular concrete as indicated on the Drawings.
   2. Maintain equipment in good operating condition and provide an adequate inventory of spare parts and backup equipment on site to ensure that equipment is available at all times.

B. Batching equipment:
   1. Utilize mechanical system of batching equipment to ensure consistency of mix.
   2. Provide digital printout record of batch scale readings, accurate to 1 pound of dry mix ingredients.

C. Foam generator:
   1. Generate foam by combining controlled quantities of air, water, and foaming agent under pressure in accordance with the foaming agent manufacturer's recommendation.
   2. Maintain the temperature of water used in generating foam below 80 degrees Fahrenheit, or as recommended by foaming agent manufacturer.
   3. Provide timer controls to repetitively discharge pre-selected quantity, or to continuously discharge at fixed rate.
   4. Discharge foam into mixer and blend with cement slurry.

D. Mixing:
   1. Configure mixer to be compatible with pump to ensure continuous and uniform flow at point of placement.
   2. Provide mixer capable of providing super-wetted, homogenized mix.
   3. Equip mixer with water meter with accuracy of within 1 gallon for measuring amount of mixing water to be added to dry mix ingredients.

E. Pumping:
   1. Provide equipment capable of pumping amounts of cellular concrete to be conveyed without pulsation or segregation.
   2. Operate pump to uniformly convey continuous stream of cellular concrete, without air pockets.

## 2.06 MIXES

A. Generate preformed foam by combining controlled quantities of air, water, and foaming agent under pressure. Foam shall retain its stability until cement sets form a self-supporting matrix.

B. Admixtures may be used to reduce water, to control set time, and to reduce washout, segregation, and bleeding. Admixtures shall be approved by foaming agent manufacturer and shall be in accordance with their recommendations.

C. Admixture content, batching method, and time of introduction to mix shall be in accordance with manufacturer's recommendations.

# PART 3 EXECUTION

## 3.01 INSTALLATION

A. General:
   1. Location where cellular concrete is to be placed shall be clean and free of extraneous material and running water.
   2. Install cellular concrete as indicated on the Drawings and specified.
      a. Abandoned in-place pipe: Place cellular concrete at access points as indicated on the Drawings .
      b. Place cellular concrete in lifts with the lift thickness not exceeding 3 feet. Wait a minimum of 6 hours between placement of lifts.
      c. After curing for 12 hours, remove any crumbling area on surface and scarified before next layer of cellular concrete is placed.

3. If ambient temperatures are anticipated to be below 40 degrees Fahrenheit within 24 hours after placement, heat mixing water when approved by manufacturer of foaming agent. If use of heated water is not approved by manufacturer of foaming agent, placement is prohibited during such period.
4. Job site batched cellular concrete mix with the foaming agent, and placed with specialized equipment certified by manufacturer.
5. Final finish surface shall be within 0.50 inch of elevations indicated on the Drawings.
6. On completion of cellular concrete placement, remove waste material, spilled grout or concrete, and construction debris from job site.

## 3.02 FIELD QUALITY CONTROL

A. Testing of cellular concrete:
   1. During progress of construction, County will have tests made to determine whether cellular concrete, as being produced, complies with specified requirements.
   2. Test cellular concrete compressive strength in accordance with ASTM C495, and mimicking in-situ pressures except:
      a. Cast cylinders using Styrofoam molds: Do not use plastic molds.
      b. Do not oven cure test specimens.
      c. Cap specimens with plaster of paris: Do not use sulfur caps.
   3. Test cellular concrete wet densities in accordance with ASTM C567.

B. Production testing:
   1. At batch plant:
      a. Test and calibrate equipment to generate foam for cellular concrete each day for density and volume output.
      b. Sample and test wet density of cellular concrete in accordance with ASTM C796 prior to introduction of the foaming agent and noting the time and temperature:
         1) Every 45 minutes.
         2) For each batch mixed.
         3) Whenever compression test cylinders are made.
   2. At placement location:
      a. Collect samples of cellular concrete at injection point or discharge point.
      b. Compressive strength tests:
         1) Take 2 sets of 2 cylinders for every 200 cubic yards batched, but no less than 2 sets per day.
         2) Test 2 cylinders at 28 days in accordance with ASTM C495, except do not oven cure test specimens.
            a) Cap test cylinders with plaster of paris. Sulfur caps are not permitted.
            b) Test additional 2 cylinders taken at 28 days.
      c. Wet density test:
         1) In accordance with ASTM C567.
         2) Sample at the connection port:
            a) Test every 30 minutes.
            b) Test after change in mix.
            c) Test whenever compressive strength test cylinders are made.

d. Immediately cease batching and placement if mix does not meet design unit weight requirement. Take corrective actions acceptable to Engineer before continuing with batching or placement.

C. For cellular concrete with test results for strength that are not within the specified range, remove and replace with cellular concrete conforming to specifications.
   1. All works associated with removal and replacement, including any other impacts to work, shall be sole responsibility of Contractor at no additional cost to County.

END OF SECTION

## SECTION 31_40_00

## SHORING, SHEETING AND BRACING

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section Includes: Work required for protection of an excavation or structure through shoring, sheeting, and bracing.

## 1.02 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Contractor's Submittals: All sheeting and bracing shall be the responsibility of the Contractor to retain qualified design services for these systems, and to be completed with strict adherence to OSHA Regulations. Submit complete design calculations and working drawings of proposed shoring, sheeting and bracing which have been prepared, signed and sealed by a Licensed Professional Engineer experienced in Structural Engineering and registered in the State of Florida, before starting excavation for jacking pits and structures. Use the soil pressure diagram shown for shoring, sheeting and bracing design. Engineer's review of calculations and working drawings will be limited to confirming that the design was prepared by a licensed professional engineer and that the soil pressure diagram shown was used.

## 1.03 REFERENCES

A. Design: Comply with all Federal and State laws and regulations applying to the design and construction of shoring, sheeting and bracing.

B. N.B.S. Building Science Series 127 "Recommended Technical Provisions for Construction Practice in Shoring and Sloping Trenches and Excavations."

## 1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Do work in accordance with the U.S. Department of Labor Safety and Health Regulations for construction promulgated under the Occupational Safety Act of 1970 (PL 91-596) and under Section 107 of the Contract Work Hours and Safety Standards Act (PL 91-54), and the Florida Trench Safety Act.

B. Observe 29 CFR 1910.46 OSHA regulations for Confined Space Entry.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS AND MATERIALS

A. Material Recommendations: Use manufacturers and materials for shoring, sheeting and bracing as recommended by the Licensed Professional Engineer who designed the shoring, sheeting, and bracing.
   1. Wood Materials: Oak, or treated fir or pine for wood lagging.

## PART 3 EXECUTION

### 3.01 SHORING, SHEETING AND BRACING INSTALLATION

A. General: Provide safe working conditions, to prevent shifting of material, to prevent damage to structures or other work, to avoid delay to the work, all in accordance with applicable safety and health regulations. Properly shore, sheet, and brace all excavations which are not cut back to the proper slope and where shown. Meet the general trenching requirements of the applicable safety and health regulations for the minimum shoring, sheeting and bracing for trench excavations.
   1. Contractor's Responsibility: Sole responsibility for the design, methods of installation, and adequacy of the shoring, sheeting and bracing.

B. Arrange shoring, sheeting and bracing so as not to place any strain on portions of completed work until the general construction has proceeded far enough to provide ample strength.

C. If Engineer is of the opinion that at any point the shoring, sheeting or bracing are inadequate or unsuited for the purpose, resubmission of design calculations and working drawings for that point may be ordered, taking into consideration the observed field conditions. If the new calculations show the need for additional shoring, sheeting and bracing, it should be installed immediately.

D. Monitoring: Periodically monitor horizontal and vertical deflections of sheeting. Submit these measurements for review.

E. Accurately locate all underground utilities and take the required measures necessary to protect them from damage. Keep all underground utilities in service at all times as specified in Division 1.

F. Driven Sheeting: Drive tight sheet piling in that portion of any excavation in paved or surface streets City collector and arterial streets and in State and County highways below the intersection of a one-on-one slope line from the nearest face of the excavation to the edge of the existing pavement or surface.

G. Sheeting Depth: In general drive or place sheeting for pipelines to a depth at elevation equal to the top of the pipe as approved.
   1. If it is necessary to drive sheeting below that elevation in order to obtain a dry trench or satisfactory working conditions, cut the sheeting off at the top of the pipe and leave in place sheeting below the top of the pipe.

2. Do not cut the sheeting until backfill has been placed and compacted to the top of the pipe.

H. Sheeting Removal: In general, remove sheeting and bracing above the top of the pipe as the excavation is refilled in a manner to avoid the caving in of the bank or disturbance to adjacent areas or structures. Remove sheeting as backfilling progresses so that the sides are always supported or when removal would not endanger the construction of adjacent structures. When required to eliminate excessive trench width or other damages, shoring or bracing shall be left in place and the top cut off at an elevation 2.5 feet below finished grade, unless otherwise directed.
   1. Carefully fill voids left by the withdrawal of the sheeting by jetting, ramming or otherwise.
   2. No separate payment will be made for filling of such voids.

END OF SECTION

## SECTION 40_05_00.01

## COMMON WORK RESULTS FOR GENERAL PIPING

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Basic materials and methods for metallic and plastic piping systems.

## 1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.

B. American Water Work Association (AWWA):
   1. C11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe.
   2. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   3. C151 - Ductile-Iron Pipe, Centrifugally Cast.
   4. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.

C. ASTM International (ASTM):
   1. A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   5. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   6. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   7. B88 - Standard Specification for Seamless Copper Water Tube.
   8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
   9. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
   10. F37 - Standard Test Methods for Sealability of Gasket Materials.
   11. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   12. F594 - Standard Specification for Stainless Steel Nuts.

13. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. California Health and Safety Code.

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health. Effects.

## 1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
   2. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
   3. Pipes adjacent to a wet wall: Pipe centerline within 10 inches of the wet wall.
   4. Underground pipes: Buried pipes - see A. above.
   5. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
   6. Wet wall: A wall with water on at least one side.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. Materials as specified in Section 01_60_00 - Product Requirements including special requirements for materials in contact with drinking water.

B. Coatings and linings requirements stated in the Pipe Schedule, as modified in the individual pipe Technical Sections, and as specified in Section 09_96_01 - High-Performance Coatings.

## 2.02 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Links to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
   4. Hardware to be Type 316 stainless steel.
      a. Provide anti-galling lubricant for threads.

B. One of the following or equal:
   1. Link-Seal.
   2. Pipe Linx.

## 2.03 FLANGE BOLTS AND NUTS

A. General:
   1. Washer:
      a. Provide a washer for each nut.
      b. Washer shall be of the same material as the nut.
   2. Nuts: Heavy hex-head.
   3. Cut and finish flange bolts to project:
      a. Face of the bolt shall exceed face of nut by 1/16-inchminimum.
      b. A maximum of 1/4 inch beyond outside face of nut after assembly.
   4. Tap holes for cap screws or stud bolts when used.
   5. Lubricant for stainless steel bolts and nuts:
      a. Chloride-free.
      b. Manufacturers: One of the following or equal:
         1) Huskey FG-1800 Anti-Seize.
         2) Weicon Anti-Seize High-Tech.

B. Ductile iron pipe:
   1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
      a. Bolts: In accordance with ASTM A307, Grade B.
      b. Nuts: In accordance with ASTM A563, Grade A.
      c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
   2. On exposed pipes with pressures greater than 150 psig:
      a. Bolts: In accordance with ASTM A193, Grade B7.
      b. Nuts: In accordance with ASTM A194, Grade 2H.
      c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
   3. On buried pipes:
      a. Bolts: In accordance with ASTM A193, Grade B8M.
      b. Nuts: In accordance with ASTM A194, Grade 8M for nuts.

## 2.04 MECHANICAL JOINTS BOLTS AND NUTS

A. Bolts, including T-bolts:
   1. Type 304 stainless steel in accordance with ASTM F593.
   2. Type 316 stainless steel in accordance with ASTM F593.

B. Heavy hex nuts:
   1. Type 304 stainless steel in accordance with ASTM F594.
   2. Type 316 stainless steel in accordance with ASTM F594.

## 2.05 GASKETS

A. General.
   1. Suitable for the specific fluids, pressure, and temperature conditions.
   2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.

B. For flanged joints in ductile iron or steel drinking water piping meeting NSF 61 requirements:
   1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 160 degrees Fahrenheit.
   2. Material:
      a. EPDM material with 80 Shore A durometer rating.
   3. Manufacturers: One of the following or equal:
      a. Garlock, 98206.
      b. John Crane, similar product.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. General:
   1. Piping drawings:
      a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
      b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
         1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
   2. Piping alternatives:
      a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
      b. Alternative pipe ratings:
         1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
         2) Piping of different material may not be substituted in lieu of specified piping.
      c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
      d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
         1) Manufacturer’s factory trained representative:
            a) Provide on-site training for Contractor’s field personnel.
            b) Periodically visit the jobsite to verify Contractor is following best recommended practices.
         2) Distributor’s representative is not considered qualified to conduct the training or jobsite visits.
      e. Flanged joints: Where one of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.
   3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
   1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
   2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
      a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
      b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
      c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
      d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
   3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
   4. Core drilled openings:
      a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by the Engineer.
      b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
      c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
   1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
      a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
         1) Slope plumbing drain piping with a minimum of 1/4-inch per foot downward in the direction of flow.
   2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
   3. Support piping adequately.
      a. Do not transfer pipe loads and strain to equipment.
   4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
   5. Assemble piping without distortion or stresses caused by misalignment:
      a. Match and properly orient flanges, unions, flexible couplings, and other connections.
      b. Do not subject piping to bending or other undue stresses when fitting piping.
      c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
      d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
      e. Alter piping assembly to fit when proper fit is not obtained.

f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
   1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
   2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
      a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
   3. Laying piping:
      a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
      b. Place piping with top or bottom markings with markings in proper position.
      c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
      d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
      e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.

E. Venting piping under pressure:
   1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
   2. Install plug valves as air bleeder cocks at high points in piping.
      a. Provide 1-inch plug valves for water lines and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
   3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
   4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion as specified in Section 09_96_01 - High-Performance Coatings.

F. Restraining buried piping:
   1. At valves and at fittings where piping changes direction, changes sizes, and at ends:
      a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
      b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
   2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
      a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
   3. Place concrete thrust blocks against undisturbed soil.
   4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
   5. Provide underground mechanical restraints where specified in Attachment A - Piping Schedule.

G. Restraining above ground piping:
    1. At valves and at fittings where piping changes direction, changes sizes, and at ends:
        a. When piping is aboveground or underwater, use mechanical or structural restraints.
        b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
    2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
        c. During testing, provide suitable temporary restraints where piping does not require permanent restraints.

H. Connections to existing piping:
    1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
        a. Protect domestic water/potable water supplies from contamination:
            1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
            2) Provide devices approved by owner of domestic water supply system to prevent flow from other sources into the domestic supply system.
    2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
    3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
    4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

I. Connections between ferrous and nonferrous metals:
    1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
    2. Nonferrous metals include aluminum, copper, and copper alloys.

J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
    1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

## 3.02 CLEANING

A. Piping cleaning:
    1. Upon completion of installation, clean piping interior of foreign matter and debris.
    2. Perform special cleaning when required by the Contract Documents.

B. Conduct pressure and leak test, as specified.

## 3.03 PIPE SCHEDULE

A. As specified in Attachment A - Pipe Schedule.

END OF SECTION

## ATTACHMENT A - PIPE SCHEDULE

## PIPE SCHEDULE

| Process Abbrev. | Service | Nominal Diameter (inches) | Material | Pressure Class Special Thickness Class Schedule Wall Thickness | Pipe Spec. Section | Joints/ Fittings | Test Pressure/ Method | Lining | Coating | Service Conditions | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D | Drain | | | | | | | | | | |
| | Underground | 2-12 | CISP | | | B&SP | 15 feet/GR | CTP | CTP | | |
| | Aboveground | 0.5-6 | GSP | SCH 40 | | SCRD | 15 feet/GR | None | EPP | | |
| PW | Potable Water | | | | | | | | | | |
| | Underground | 3-36 | DIP | CL 53 | | RMJ or RPJ | 225 psig/HH | CM | EPU-M-1 | | |
| | Aboveground | 3-36 | DIP | CL 53 | | FL | 225 psig/HH | CM | EPU-M-1 | | |

Abbreviations:

1. The following abbreviations used in the column of test method refer to the respective methods.
   - AM Air method
   - GR Gravity method
   - HH High head method
   - LH Low head method
   - SC Special case
2. Abbreviations to designate piping include the following:
   - B&SP Bell and spigot
   - BSP Black Steel Pipe
   - CE Ceramic epoxy lining
   - CI Cast iron
   - CISP Cast iron soil pipe
   - CL Class, followed by the designation
   - CM Cement mortar
   - CTP Coal tar pitch
   - DIP Ductile iron piping
   - EPP Epoxy polyurethane coating
   - FL Flange
   - GA Gauge, preceded by the designation
   - GE Grooved end joint
   - GL Glass lined
   - GSP Galvanized steel pipe
   - MJ Mechanical joint
   - MWA Mechanical wedge action
   - NPS Nominal pipe size, followed by the number in inches
   - psi pounds per square inch
   - psig pounds per square inch gauge
   - PE Polyethylene
   - PEE Polyethylene encasement
   - PTW Polyethylene tape wrap
   - PVC Polyvinyl Chloride
   - RPO Restrained push-on
   - SCH Schedule, followed by the designation
   - SCRD Screwed-on
   - SST Stainless steel
   - SW Solvent welded
   - VCP Vitrified clay piping
   - WLD Weld

## SECTION 40_05_00.09

## PIPING SYSTEMS TESTING

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

## 1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.3 - Process Piping.
   3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

## 1.03 TESTING REQUIREMENTS

A. General requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping; are specified in the specifications covering the various types of piping; and are specified in this Section.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01_41_00 - Regulatory Requirements, and UL requirements.
   4. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
      a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

D. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

E. Test completion: Drain and leave piping clean after successful testing.

F. Test water disposal: Dispose of testing water in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site. All requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be responsibility of Contractor.

## 1.04 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
   3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

## 1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

# PART 2 PRODUCTS (NOT USED)

# PART 3 EXECUTION

## 3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:

1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

## 3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
   1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping:
   1. Provide temporary pressure relief valve for piping under test:
      a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
   2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASME B31.8, or the pipe manufacturer's stated maximum working pressure.
   3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
   4. Perform initial check of joints and fittings for leakage.
   5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage; at each step increase until test pressure reached.
   6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
   7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

## 3.03 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.

b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
    1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
        a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
            (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
        b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.
        c) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

## 3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.

B. General:
1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
6. When test results indicate failure of selected sections, limit tests to piping:
    a. Between valves.
    b. Between a valve and the end of the piping.
    c. Less than 500 feet long.
7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
1. Fill piping section under test slowly with water while venting air:
    a. Use potable water for all potable waterlines and where noted on the Piping Schedule.

2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
    a. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
2. Pressure test piping after completion of visible leaks test.
3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
    a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
    b. Successful completion of the pressure test with maximum leakage allowance shall be achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
    c. When leakage is allowed, calculate the allowable leakage by the following formula:

        $L = S \times D \times P^{1/2} \times 148{,}000^{-1}$

        wherein the terms shall mean:

        L = Allowable leakage in gallons per hour.

        S = Length of the test section in feet.

        D = Nominal diameter of the piping in inches.

        P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

        x = The multiplication symbol.

## 3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
1. Test pressures shall be as scheduled in Section 40_05_00.01 - Common Work Results for General Piping.

2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:
1. Subject piping under test to specified pressure measured at the lowest end.
2. Fill piping section under test slowly with water while venting air:
   a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
1. Pressure test piping after completion of visible leaks test.
2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
   a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
   b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

END OF SECTION

## SECTION 40_05_06.03

## PIPE COUPLINGS

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Pipe couplings for ductile iron piping.
   2. Pipe couplings for carbon steel piping.
   3. Pipe couplings for stainless steel piping.

## 1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
   3. C213 - Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   4. C219 - Bolted, Sleeve-Type Couplings For Plain-End Pipe.
   5. C606 - Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   6. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
   7. A536 - Standard Specification for Ductile Iron Castings.
   8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   9. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.

10. C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
11. C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
12. C564 - Standard Specification for Rubber Gasket for Cast Iron Pipe and Fittings.
13. C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
14. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
15. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
16. D5926 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
17. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
18. F594 - Standard Specification for Stainless Steel Nuts.
19. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
2. 372 - Drinking Water System Components - Lead Content.

## 1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data:
1. For each product in this Section as applicable:
a. Design features.
b. Load capacities.
c. Material designations by UNS alloy number or ASTM Specification and Grade.
d. Data needed to verify compliance with the Specifications.
e. Catalog data.
f. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.

C. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

## 1.04 WARRANTY

A. Provide warranty as described in the Construction Services Agreement.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. As specified in Section 01_60_00 - Product Requirements:
   1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

B. Known acceptable manufacturers are listed by specific products.

C. Provide references as specified in this Section by specific product.

D. Manufacturer's representatives requirements as specified in Section 01_75_17 - Commissioning and this Section by specific product.

E. Gaskets for flexible couplings and flanged coupling adapters:
   1. Provide gasket materials for piping applications as follows:
      a. Low-pressure and high-pressure air, steam, hot water: EPDM.
      b. All other piping applications: EPDM.

F. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Kop-Coat Co., Inc., Bitumastic Number 50.
      b. Tapecoat Co., Inc., T.C. Mastic.
   2. Thickness: Minimum 0.040 inch.

### 2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Restrained flange coupling adapter:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style RFCA.
      b. Star Pipe Products, 3200 StarFlange™.
   2. Materials:
      a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
      b. Follower ring: Lug type restraint system.
         1) Follower ring: Ductile iron in accordance with ASTM A536.
         2) Restraining lugs: Ductile iron in accordance with ASTM A536.
            a) Designed to contact the pipe and apply forces evenly.
         3) Restraining bolts:
            a) Ductile iron in accordance with ASTM A536.
            b) Bolt heads shall be designed to twist off when the proper torque has been applied.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

B. Grooved joint couplings:
   1. Manufacturers: The following or equal:
      a. Victaulic Co., Series 31 or equal.
   2. Materials:
      a. Housings: Ductile iron in accordance with ASTM A536.
      b. Gasket:
         1) FlushSeal® type, or equal. Elastomer in accordance with ASTM D2000.
         2) EPDM
      c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
      d. Coating: As specified in Section 09_96_01 - High-Performance Coatings.
   3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
   4. For connection to IPS steel pipe sizes, Victaulic Style 307.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with the manufacturer's instructions.

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
   1. Install flexible coupling with pipe gap located in middle of center sleeve.
   2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

| Center Ring Length | Gap Dimension and Tolerance |
|---|---|
| 4 inch through 6 inch | 3/8 inch |
| 7 inch | 5/8 inch |
| 10 inch and greater | 7/8 inch |

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
   1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 40_05_00.01 - Common Work Results for General Piping.

E. Grooved joint couplings:
   1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
   2. Gaskets: Elastomer grade suitable for the intended service, and molded and produced by the coupling manufacturer.

END OF SECTION

## SECTION 40_05_19.01

## DUCTILE IRON PIPE: AWWA C151

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Ductile iron pipe, joints, connections, fittings, and pipe linings and coatings.

B. As specified in Section 40_05_00.01 - Common Work Results for General Piping.

## 1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   6. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
   7. C153 - Standard for Ductile-Iron Compact Fittings for Water Service.
   8. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   9. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   10. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
   11. C606 - Standard for Grooved and Shouldered Joints.

C. American Welding Society (AWS):
   1. D11.2 - Guide for Welding Iron Castings.

D. ASTM International (ASTM):
   1. A536 - Standard Specifications for Ductile Iron Castings.
   2. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-Lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.
   3. C33 - Standard Specification for Concrete Aggregates.
   4. C150 - Standard Specification for Portland Cement.
   5. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
   6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   7. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

E. Ductile Iron Pipe Research Association (DIPRA):
   1. Thrust Restraint Design Manual.

F. International Organization for Standardization (ISO):
   1. 8179 - Ductile iron pipe, fittings, accessories and their joints - External zinc-based coating - Part 1: Metallic zinc with finishing layer.

G. National Association of Pipe Fabricators, Inc. (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

I. Society for Protective Coatings (SSPC):
   1. SP 5 - White Metal Blast Cleaning.
   2. PA 2 - Measurement of Dry Coating Thickness with Magnetic Gages.

## 1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data.

C. Manufacturer's qualifications.
   1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.

D. Manufacturer's Quality Assurance Manual:
   1. Submit manufacturer's coating and lining application quality assurance manual to the Engineer prior to beginning coating application.
      a. Strict conformance to the requirements of the manual will be required.
      b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

E. Shop Drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
   2. Thrust restraint systems.
   3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.

F. Calculations:
   1. Thrust restraint system design.

G. Manufacturer's Certificate of Source Testing for ceramic epoxy, glass lined, plural component polyurethane, and zinc materials:
   1. Certify successful performance of holiday detection tests on 100 percent of lining in accordance with ASTM B1000.

2. Identify each test piece by mark designation and show the actual test results during the final inspection by the manufacturer prior to shipment.
3. Zinc coating: Regular measurements in accordance with ISO 8179 Part 4.4.
4. Include coating manufacturer's technical representative's reports.

## 1.04 QUALITY ASSURANCE

A. Ductile iron pipe shall be supplied by a single manufacturer.

B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.

C. Pre-installation meeting:
1. Arrange for coating manufacturer's technical representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

## 1.05 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle piping and associated fittings during loading, unloading, and installation:
1. Do not drop piping material from cars or trucks.
2. Lower piping by mechanical means.
3. Do not drop or pound pipe to fit grade.

C. Handle pipe from the outside if lined with ceramic epoxy, glass or plural component polyurethane.
1. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.

D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

# PART 2 PRODUCTS

## 2.01 MANUFACTURED UNITS

A. Ductile iron piping:
1. Manufacturers: One of the following or equal:
a. American Cast Iron Pipe Co.
b. McWane Ductile.
c. SIP Industries.
d. U.S. Pipe.

## 2.02 THRUST RESTRAINT SYSTEM DESIGN

A. Length of pipe that must be restrained on each side of the focus of a thrust load as indicated on the Drawings.

B. Design pressure: Test pressure.

C. Laying condition: Type 3 in accordance with AWWA C150.

D. Soil type: Silt 1.

E. Unit friction resistance for polyethylene encasement of pipe: DIPRA factor multiplied by a safety factor of 1.5.

## 2.03 CONCRETE THRUST BLOCK RESTRAINT

A. Joint thrust restraint system designed by the Contractor.
   1. Concrete thrust blocks will not be permitted for DIP restraint.

## 2.04 DUCTILE IRON JOINTS AND CONNECTIONS

A. General:
   1. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
   2. In accordance with AWWA C150 and AWWA C151.
   3. Joints:
      a. Flanged.
      b. Grooved.
      c. Mechanical.
      d. Push-on rubber gasket.
      e. Integrally restrained mechanical.
      f. Mechanical wedge action.
      g. Integrally restrained push-on.
      h. Push-on joint restraint harness.
   4. Connections:
      a. Tapping saddle.
      b. Tapping sleeve.
      c. Welded outlet.
   5. Fittings.

B. Joints:
   1. Flanged joints:
      a. Screw-on flanges:
         1) Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1.
         2) Ductile iron.
         3) Long hub, threaded, and specially designed for ductile iron pipe.
         4) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.

d. Bolts and nuts:
    1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
e. Gaskets:
    1) Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 40_05_00.01 - Common Work Results for General Piping.

2. Mechanical joints:
    a. In accordance with AWWA C111.
    b. Gaskets:
        1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
    c. Bolts and nuts, including T-bolts:
        1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
3. Push-on rubber gasket joints:
    a. In accordance with AWWA C111.
    b. Gaskets:
        1) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
4. Mechanical wedge action joint restraints:
    a. Manufacturers: One of the following or equal:
        1) EBAA Iron, Inc., Megalug® Series 1100.
        2) Sigma Corp., One-Lok Model SLDE.
        3) Star Pipe Products, Split Stargrip Series 3000.
    b. Materials:
        1) Gland body:
            a) Ductile iron in accordance with ASTM A536.
        2) Wedges and wedge actuating components:
            a) Ductile iron in accordance with ASTM A536.
            b) Wedges shall be heat treated to a minimum of 370 BHN.
        3) Actuating bolts and nuts:
            a) Ductile iron in accordance with ASTM A536.
            b) Provide torque-limiting twist off components to ensure proper installation.
        4) Gaskets:
            a) As specified in Section 40_05_00.01 - Common Work Results for General Piping.
    c. Coatings:
        1) Provide manufacturer applied coating system.
        2) Manufacturers: One of the following or equal:
            a) EBAA Iron Inc., Mega-Bond.
            b) Sigma Corp., Corrsafe™ Electro-deposition coating.
            c) Star Pipe Products, Star-Bond.
    d. Working pressure:
        1) Shall include a minimum safety factor of 2:1.
        2) Sizes 3- through 16-inch: 350 pounds per square inch.
        3) Sizes 18- through 48-inch: 250 pounds per square inch.
    e. Restraint shall consist of multiple gripping wedges incorporated into a follower gland meeting the requirements of AWWA C111.

f. Restraint shall allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
g. Restraint must be in accordance with applicable requirements of AWWA C110 and AWWA C111 for mechanical joints.

C. Connections:
1. All tapping sleeve and valve assemblies shall meet the requirements of WWA Standard C500, latest revision. Cast iron tapping sleeves or stainless steel wrap-around sleeves, and cast iron valves shall be used to make live taps into the existing water mains where shown on the drawings. Flanges must conform to AWWA C207 Class D ANSI 150# drilling. Mechanical Joint (MJ) tapping sleeves are also acceptable. All bolts and nuts shall be stainless steel
2. CONTRACTOR shall verify type of existing main prior to ordering. The tapping valve shall have an inlet flange to match the sleeve and a mechanical joint outlet for connection to water main pipe. Tapping valve shall meet the requirements for gate valves specified herein. The sleeve shall have provisions for a tap and shall be pressure tested at 200 psi for a minimum of 30 minutes prior to tapping.
3. Welded outlet:
a. Not allowed without Engineer approval.

D. Fittings:
1. Ductile iron in accordance with AWWA C110 or AWWA C153.
2. Joint type:
a. Same as that of the associated piping as specified in Section 40_05_00.01 - Common Work Results for General Piping.
3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

## 2.05 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C104 and as specified in this Section.

B. Cement:
1. Cement: In accordance with ASTM C150, Type V.

C. Water:
1. In accordance with AWWA C104 and as specified in this Section.

D. Sand and aggregate:
1. In accordance with AWWA C104.
2. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

E. Lining:
1. Minimum thickness: Standard in accordance with AWWA C104.
2. Apply cement mortar on clean bare metal surfaces.
3. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
4. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
a. Extend to faces of flanges and ends of spigots.

b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.

5. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
6. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C104 and approved by the Engineer.
   a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
      1) No. 12 gauge spaced at maximum 1-inch centers.
      2) No. 14 gauge steel wire at maximum 1/2-inch centers.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 40_05_00.01 - Common Work Results for General Piping.
   2. For underground piping, the trenching, backfill, and compaction:
      a. Inspect coating prior to backfill.

B. Joints:
   1. Install types of joints as specified in the piping schedule provided in Section 40_05_00.01 - Common Work Results for General Piping.
   2. Mechanical joints are not acceptable in above ground applications.
   3. Field closure for restrained push-on pipe:
      a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
   4. Grooved joints:
      a. Install piping with grooved joints where specified in the piping schedule as specified in Section 40_05_00.01 - Common Work Results for General Piping.
      b. Assemble grooved joints in accordance with manufacturer’s published instructions.
      c. Support grooved-end pipe in accordance with manufacturer’s published instructions.
         1) Install at least 1 support between consecutive couplings.

C. Connection:
   1. Tapping ductile iron pipe:
      a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
         1) Maximum allowable tap diameter by pipe diameter and pressure class:

| Pipe Size (inches) | Pressure Class | | | | |
|---|---|---|---|---|---|
| | 150 | 200 | 250 | 300 | 350 |
| | Maximum Allowable Direct Tap Size (inches) | | | | |
| 3 | - | - | - | - | 3/4 |
| 4 | - | - | - | - | 3/4 |
| 6 | - | - | - | - | 1 |
| 8 | - | - | - | - | 1 |
| 10 | - | - | - | - | 1 |
| 12 | - | - | - | - | 1-1/4 |
| 14 | - | - | 1-1/4 | 1-1/2 | 1-1/2 |
| 16 | - | - | 1-1/2 | 2 | 2 |
| 18 | - | - | 2 | 2 | 2 |
| 20 | - | - | 2 | 2 | 2 |
| 24 | - | 2 | 2 | 2 | 2 |

b. Maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

2. Direct tapping of glass lined ductile iron pipe may be performed only when approved in writing by the Engineer. Direct tapping of glass lined pipe shall be performed in accordance with the above conditions for tapping ductile iron pipe in addition to the following conditions:
   a. Drilling and tapping shall be performed using a hole saw.
      1) Use of a large drill bit is not acceptable.
   b. As the hole saw approaches the glass lining, lessen the inward pressure to avoid excess chipping or cracking of the lining.
   c. Minor chipping or spalling of the glass lining shall be repaired using an epoxy resin “glass repair kit” provided by the fabricator.
      1) Manufacturers: One of the following or equal:
         a) Devoe - Devran 224 HS.
         b) Sherwin-Williams Co. - Sher-Tile High Solids Epoxy.
      2) Repair kit use is only allowed for areas of damage less than 1/2 inch in diameter.
         a) Larger areas of damage will require replacement.
      3) Surface shall be prepared and repair kit shall be applied in accordance with manufacturer and/or fabricator’s instructions.
   d. the environmental conditions necessary for proper coating application.

## 3.02 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
   1. Test as specified in Section 40_05_00.01 - Common Work Results for General Piping.

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
   1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

END OF SECTION

## SECTION 40_05_51.01

## COMMON WORK RESULTS FOR VALVES

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes: Basic requirements for valves.

## 1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   3. A536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
   1. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - Near-White Blast Cleaning.

## 1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      d. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      e. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Provide vendor operation and maintenance manual as specified in Section 01_78_24 - Operation and Maintenance Manuals.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

## 1.04 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

## 1.05 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

# PART 2 PRODUCTS

## 2.01 DESIGN AND PERFORMANCE CRITERIA

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Metallic valves:
      a. Valves 3 inches nominal size and larger: Flanged ends.
      b. Valves less than 3 inches nominal size: Screwed ends.
   2. Plastic valves in plastic piping systems:
      a. Up to 4 inches: Provide solvent or heat welded unions, except for plastic butterfly valves.
         1) Plastic butterfly valves shall be flanged.
      b. 6 inches and above: Provide solvent or heat-welded flanges.

## 2.02 MATERIALS

A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts (not including flange bolts and nuts, which are specified in Section 40_05_00.01 - Common Work Results for General Piping):
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.

E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

## 2.03 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: The following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012-inch, except that:
         1) Lining thickness in grooves for gaskets: 0.005-inch.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
         4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
         5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
    a. Product equivalent to high solids epoxy as specified in Section 09_96_01 - High-Performance Coatings.
        1) Certified in accordance with NSF 61 for drinking water use.
        2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy as specified in Section 09_96_01 - High-Performance Coatings.
    b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
    c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
        1) Repair holidays and other irregularities and retest coating.
        2) Repeat procedure until holidays and other irregularities are corrected.

## 2.04 UNDERGROUND VALVES

A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.

B. Coating and wrapping:
    1. After installation, encase valves in polyethylene wrap as specified for ductile iron piping in Section 40_05_19.01 - Ductile Iron Pipe: AWWA C151.
        a. Ascertain that polyethylene wrapping does not affect operation of valve.

## 2.05 VALVE BOXES

A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.

B. Do not support boxes on valve, valve operator, or pipe.

C. Boxes:
    1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
    2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

D. Manufacturers: One of the following or equal:
    1. Tyler Pipe Industries, Inc.
    2. Neenah Foundry Co.

## 2.06 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels, as indicated on the Drawings.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
   2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

### 3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Valve and actuator orientation:
   1. Contractor shall coordinate with valve supplier final orientation of valve and actuator assembly based on Contractor's selection of equipment manufacturers and the valve and piping arrangement as indicated on the Drawings.
      a. Contractor shall rotate valve and/or actuator mounting orientation as specified in this Section unless otherwise indicated on the Drawings.
   2. Install valves with their stems in vertical position above the pipe, except as follows:
      a. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
      b. Install buried plug valves with geared operators with their stems in a horizontal position.
   3. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

D. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

E. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon™ tape on external (male) threads to prevent forcing compound into valve seat area.

F. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

G. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

## 3.03 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09_96_01 - High-Performance Coatings.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

## 3.04 COMMISSIONING

A. As specified in Section 01_75_17 - Commissioning and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes or actuators.
   1. Source testing.
   2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION

# SECTION 40_05_65.01

# GATE, GLOBE, AND ANGLE VALVES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Gate, globe (non-pilot controlled), and needle valves.
   2. As specified in Section 40_05_51.01 - Common Work Results for Valves.

### 1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 inch Standard.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 through NPS 60 inch Standard.

B. American Water Works Association (AWWA):
   1. C515 - Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
   2. C550 - Protective Interior Coatings for Valves and Hydrants.

C. ASTM International (ASTM):
   1. B98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data:
   1. As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. Commissioning Submittals:
   1. For valves larger than 16 inches:
      a. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

### 1.04 WARRANTY

A. As described in the Construction Services Agreement.

B. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves comply in accordance with all provisions of AWWA C550.

## PART 2 PRODUCTS

### 2.01 GATE VALVES - GENERAL SERVICE (GV00)

A. Underground:
   1. Manufacturers: One of the following, or equal:
      a. American Flow Control.
      b. M&H/Kennedy Valve Co.
      c. Mueller Co.
   2. Design:
      a. Size, material, configuration: Indicated on the Drawings.
      b. Resilient wedge type in accordance with AWWA C515.
      c. Stem:
         1) Iron body, resilient seat, non-rising stem, double O-ring stem seal.
      d. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
      e. Bronze stem with double or triple O-ring or braided packing stem seals.
      f. Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.
      g. Valve operator: Provide standard AWWA 2-inch operating nut, matching valve key, and valve box for operating stem.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Mount yard hydrants on minimum 1-inch supply pipe or size indicated on the Drawings.

B. Mount post hydrants on minimum 2-inch supply pipe or size indicated on the Drawings.

C. Set yard and post hydrants in 4 cubic feet of 3/4-inch minimum crushed stone surrounding valve body to allow for proper drainage.
   1. Install in accordance with AWWA recommendations for hydrants.

### 3.02 COMMISSIONING

A. As specified in Section 01_75_17 - Commissioning and this Section.

B. Manufacturer services: For valves larger than 16 inches.
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

# SECTION 40_05_67.40

# AIR AND VACUUM RELIEF VALVES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Air release valves, air and vacuum valves, and air vents.

B. As specified in Section 40_05_51.01 - Common Work Results for Valves.

### 1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.

B. American Water Works Association (AWWA).

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   3. A270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
   4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01_33_00 - Submittal Procedures.

B. Product data: As specified in Section 40_05_51.01 - Common Work Results for Valves.

C. Commissioning Submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

### 1.04 WARRANTY

A. Provide warranty as specified in Section 01_78_36 - Warranties and Bond.

## PART 2 PRODUCTS

### 2.01 METAL BODY AIR RELEASE VALVES - WATER SERVICE (ARV00)

A. Manufacturers: One of the following or equal:
   1. Multiplex Manufacturing Co., Crispin PL Series.
   2. Valve and Primer Corp., DeZURIK/APCO Series 200.

B. Design:
   1. Pressure rating: 150 pounds per square inch gauge unless differently indicated on the Drawings.
   2. Provide low pressure seat when the operating pressure is below 10 psi.
   3. Inlet: Screwed, 2-inch.
   4. Orifice size: 1/4inch diameter.

C. Materials:
   1. Valve body: Cast iron.
   2. Float and internal trim: Type 316 stainless steel.
   3. Seat or valve plunger: Buna-N.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install as specified in Section 40_05_51.01 - Common Work Results for Valves and the manufacturer's instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

### 3.02 COMMISSIONING

A. As specified in Section 01_75_17 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 40_05_51.01 - Common Work Results for Valves.

END OF SECTION

## SECTION 40_90_00

## INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

# PART 1 GENERAL

## 1.01 SUMMARY

A. This section gives general requirements for Process Instrumentation and Control (PIC). The following PIC subsections expand on requirements of this section:
   1. Section 40_91_00, Instrumentation and Control Components.

B. Major Work Items: Includes but is not limited to engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and training for complete PICS.
   1. Process instrumentation including primary elements, transmitters, control devices, and control panels.
   2. Programmable controllers.
   3. Computers and networks for Human Machine Interface (HMI).

C. Applications Software: Provided by Process Control Consultant (Owner's programmer) for PLC and HMI, not part of this contract. Work related to support this activity and it is part of this contract includes:
   1. Assistance with onsite checkout of applications software.
   2. For additional related requirements refer to:
      a. Article Sequencing and Scheduling in this section.
      b. Sections that cover the equipment for which Process Control Consultant will provide applications software.

## 1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section and other PIC subsections:
   1. American National Standards Institute (ANSI).
   2. ASTM International (ASTM):
      a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
      b. A276, Standard Specification for Stainless Steel Bars and Shapes.
      c. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
      d. B32, Standard Specification for Solder Metal.
      e. B88, Standard Specification for Seamless Copper Water Tube.
   3. Deutsche Industries-Norm (DIN): VDE 0611, Specification for modular terminal blocks for connection of copper conductors up to 1,000V ac and up to 1,200V dc.
   4. Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

5. The Instrument, Systems, and Automation Society (ISA):
    a. RP12.06.01, Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety.
    b. S5.1, Instrumentation Symbols and Identification.
    c. S5.4, Instrument Loop Diagrams.
    d. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
    e. TR20.00.01, Specification Forms for Process Measurement and Control Instruments, Part 1: General.
6. International Conference on Energy Conversion and Application (ICECA).
7. National Electrical Code (NEC).
8. National Electrical Manufacturers Association (NEMA):
    a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
    b. ICS 1, Industrial Control and Systems General Requirements.
9. National Fire Protection Association (NFPA): 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
10. Underwriters Laboratory, Inc. (UL): 508A, Standard for Safety, Industrial Control Panels.

## 1.03 DEFINITIONS

A. Abbreviations:
    1. DCU: Distributed Control Unit.
    2. FDT: Factory Demonstration Test.
    3. HMI: Human-Machine Interface.
    4. HVAC: Heating, Ventilating, and Air Conditioning.
    5. I&C: Instrumentation and Control.
    6. I/O: Input and Output.
    7. O&M: Operation and Maintenance.
    8. P&ID: Process and Instrument Diagram.
    9. PC: Personal Computer.
    10. PIC: Process Instrumentation and Control.
    11. PLC: Programmable Logic Controller.
    12. RTU: Remote Terminal Unit.
    13. SCADA: Supervisory Control and Data Acquisition.
    14. SLDC: Single Loop Digital Controller.

B. Enclosure: Control panel, console, cabinet, or instrument housing.

C. Instructor Day: Eight hours of actual instruction time.

D. Standard Software: Software packages that are independent of Project on which they are used. Standard software includes system software, supervisory control, and data acquisition (SCADA) software.
    1. System Software: Application independent (non-project specific) software developed by digital equipment manufacturers and software companies. Includes, but is not limited to, operating systems; network support, programming languages (C, C++, Visual C++, BASIC, Visual Basic, etc); Office Suites (word processor, spreadsheet, database, etc.); e-mail; security (firewall, antivirus; spam, spyware, etc.) debugging aids; and diagnostics.

2. SCADA Software: Software packages independent of specific process control project on which they are used. Includes, but is not limited to, providing configuring and run-time capability for, data acquisition (I/O driver, OPC servers, etc.), monitoring, alarming, human-machine interface, supervisory control, data collection, data retrieval, trending, report generation, control, and diagnostics.
3. Controller Programming Software: Software packages for the configuring of PLCs, RTUs, DCUs, SLDC, and field bus devices.

E. Application Software: Software to provide functions unique to this Project and that are not provided by standard software alone, including but not limited to:
1. Configuring databases, tables, displays, historians, reports, parameter lists, ladder logic, function block, and control strategies required to implement functions unique to this Project.
2. Programming in any programming or scripting language.

F. Process Control Consultant: Entity to be hired by owner for Application Software development on HMI and PLC.

G. Rising/Falling: Define action of discrete devices about their set point.
1. Rising: Contacts close when an increasing process variable rises through set point.
2. Falling: Contacts close when a decreasing process variable falls through set point.

H. Staging Site: Location of staging site demonstration testing and subsequent Process Control Consultant's development of application software. Site provide by Process Control Consultant.

I. Signal Types:
1. Analog Signal, Current Type:
a. 4 to 20 mA dc signals conforming to ISA S50.1.
b. Unless otherwise indicated for specific PIC subsection components, use the following ISA S50.1 options.
1) Transmitter Type: Number 2, two-wire.
2) Transmitter Load Resistance Capacity: Class L.
3) Fully isolated transmitters and receivers.
2. Analog Signal, Voltage Type: 1 to 5 volts dc within panel where common high precision dropping resistor is used.
3. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.
4. Pulse Frequency Signals:
a. Direct-current pulses whose repetition rate is linearly proportional to process variable.
b. Pulses generated by contact closures or solid state switches.
c. Power source less than 30V dc.
5. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

## 1.04 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Complete detailed design of PIC components and PIC drawings.
   2. Provide consistent hardware and software functions for PIC. For example, provide functions in control logic, sequence controls, and display layouts in same or similar manner.
   3. PIC design as shown and specified includes:
      a. Functional requirements, performance requirements, and component specifications.
      b. P&IDs, block diagrams, and network diagrams.
   4. Typical drawings for installation details, control panel layouts, control panel schedules, PLC I/O module wiring, panel power, and control diagrams.

B. Use a qualified PIC System Integrator for at least the following work:
   1. For PIC Equipment and Ancillaries:
      a. Completing detail design.
      b. Submittals.
      c. Equipment, enclosures, and ancillaries.
      d. Verify readiness for operation.
      e. Verify correctness of final power and signal connections (lugging and connecting).
      f. Adjusting and calibrating.
      g. Starting up.
      h. Testing and coordination of testing.
      i. Training.
      j. Assist Process Control Consultant with Functional Test Part 2 as defined in Article Field Quality Control.
   2. Verify following Work not by PIC System Integrator is provided:
      a. Correct type, size, and number of signal wires with their raceways.
      b. Correct electrical power circuits and raceways.
      c. Correct size, type, and number of PIC-related pipes, valves, fittings, and tubes.
      d. Correct size, type, materials, and connections of process mechanical piping for in-line primary elements.
   3. Non-PIC Equipment Directly Connected to PIC Equipment:
      a. Obtain from Contractor, manufacturers' information on installation, interface, function, and adjustment.
      b. Coordinate with Contractor to allow required interface and operation with PIC.
      c. For operation and control, verify installations, interfacing signal terminations, and adjustments have been completed in accordance with manufacturer's recommendations.
      d. Test to demonstrate required interface and operation with PIC.
      e. Examples of items in this category, but not limited to the following:
         1) Valve operators, position switches, and controls.
         2) Chemical feed pump and feeder speed/stroke controls.
         3) Automatic samplers.
         4) Motor control centers.
         5) Adjustable speed and adjustable frequency drive systems.

f. Examples of items not in this category:
1) Internal portions of equipment provided under Division 26, Electrical, that are not directly connected to PIC equipment.
2) Internal portions of package system instrumentation and controls that are not directly connected to PIC equipment.

## 1.05 SUBMITTALS

A. General:
1. Submit proposed Submittal breakdown consisting of sequencing and packaging of information in accordance with Project Schedule.
2. Partial Submittals not in accordance with Progress Schedule will not be accepted.
3. Submittal Format:
a. Hard Copy: Required for Third Stage submittals.
b. All submittals to be in Electronic format: unless otherwise noted for specific items.
1) Manufacturers' Standard Documents: Adobe Acrobat PDF.
2) Documents created specifically for Project:
a) Text and Graphics: Microsoft Word.
b) Lists: Microsoft Excel, unless otherwise noted for specific items.
c) Drawings: AutoCAD.
4. Identify proposed items, options, installed spares, and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
5. Legends and Abbreviation Lists:
a. Definition of symbols and abbreviations used; for example, engineering units, flowstream, instruments, structures, and other process items used in nameplates, legends, data sheets, point descriptions, HMI displays, alarm/status logs, and reports.
b. Use identical abbreviations in PIC subsections.
c. Submit updated versions as they occur.
6. Activity Completion:
a. First and Second Stage Submittals: Completed when reviewed and approved.
b. Third Stage Submittals: Completed when reviewed and found to meet conditions of the Contract.

B. First Stage Submittal:
1. A detailed list of any exceptions, functional differences, or discrepancies proposed by System Supplier that differ from design or FKAA standards.
a. Provide an itemized list of exceptions from the contract with a reason an exception is needed as well as the proposed substitution.
1) Identify any cost or schedule impacts because of the exception
2. Wiring Diagram Submittal
a. Example drawings for each I/O types (DI, DO, AO, AI 2 wire, AI 4 wire) including fusing, surge and non-surge protected circuits
3. Fiber Optic Cable Submittals in accordance Fiber Optic Cable Submittals.
4. Draft Control Narratives.
5. Complete I/O List.
6. Communication drawings.

7. Development system as specified in Section 40_91_00, Instrumentation and Control Components.
8. Bill of Materials: List of required equipment.
    a. Group equipment items by enclosure and field, and within an enclosure, as follows:
        1) PIC Components: By component identification code.
        2) Other Equipment: By equipment type.
    b. Data Included:
        1) Equipment tag number.
        2) Description.
        3) Manufacturer, complete model number and all options not defined by model number.
        4) Quantity supplied.
        5) Component identification code where applicable.
        6) For panels, include panel reference number and name plate inscription.
    c. Formats: Electronic copy in Microsoft Excel.
9. Proposed Catalog Cuts: I&C components, electrical devices, and mechanical devices:
    a. Catalog information, marked to identify proposed items and options.
    b. Descriptive literature.
    c. External power and signal connections.
    d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
10. Instrument List:
    a. Applicable fields to be completed include, but are not limited to:
        1) Tag Number.
        2) Loop Number.
        3) Description.
        4) Manufacturer and complete model number.
        5) Size and scale range.
        6) Set points.
        7) Reference P&IDs, Electrical, Mechanical, Interconnection Drawings.
        8) Installation Details Drawings.
        9) Instrument detail number.
    b. Submit updated version of Instrument List.
    c. Electronic Copies: Microsoft Excel.
11. Component Data Sheets: Data sheets for I&C components.
    a. Format:
        1) Similar to ISA TR20.00.01.
        2) Microsoft Excel, one component per data sheet.
        3) Submit proposed format for Component Data Sheets before completing data sheets for individual components.
    b. Content: Specific features and configuration data for each component, including but not limited to:
        1) Tag Number.
        2) Component type identification code and description.
        3) Location or service.
        4) Service conditions.
        5) Manufacturer and complete model number.
        6) Size and scale range.

7) Set points.
8) Materials of construction.
9) Options included.
10) Power requirements.
11) Signal interfaces.
12) Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.

c. Electronic Copies: Microsoft Excel.

12. Sizing and Selection Calculations:
    a. Primary Elements:
        1) Complete calculations plus process data used. Example for Flow Elements:
            a) Minimum and maximum values, permanent head loss, and assumptions made.
    b. Controller, Computing, and Function Generating Modules: Actual scaling factors with units and how they were computed.
    c. Electronic Copies: Microsoft Excel, one file for each group of components with identical sizing calculations.
13. Preliminary Panel Elevation Drawings: Provide prior to submitting Panel Construction Drawings:
    a. Scale Drawings: Show dimensions and location of front of panel devices.
    b. Panel Legend (Bill of Material): List front of panel devices by tag number. Include nameplate inscriptions, service legends, and annunciator inscriptions.
    c. Submit electronic copies of Drawings.

C. Second Stage Submittal:
1. Panel Construction Drawings:
    a. Scale Drawings: Show dimensions and locations of panel-mounted devices, doors, louvers, subpanels, internal and external. Provide scaled front of panel arrangement to show general appearance, with spacing and mounting height of instruments and control devices.
    b. Panel Legend (Bill of Material): List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
    c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
    d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, weight and welding and other connection callouts and details.
    e. Construction Notes: Finishes, wire color schemes, wire ratings, wire, terminal block numbering, and labeling scheme.
    f. Submit electronic copies of Drawings.
2. Panel Wiring Diagrams:
    a. Cover wiring within a panel including, but not limited to, instrumentation, control, power, and communications, and digital networks.
    b. Objectives: For use in wiring panels, making panel connections, and future panel trouble shooting.

c. Diagram Type:
    1) Ladder diagrams where applicable. Include devices that are mounted in or on the panel that require electrical connections. Show unique rung numbers on left side of each rung.
    2) Schematic drawings for wiring of circuits that cannot be well represented by ladder diagrams.
d. Wiring diagrams shall show complete circuits and indicate all connections. If panel terminal designations, interdevice connections, device features and options, or other features are modified during the fabrication or factory testing, revised drawings shall be submitted before shipment of the equipment to the site.
    1) Include wiring colors.
    2) Include field wire labels.
    3) Include terminal identifications.
    4) Include junction box or field panel identifications.
e. Item Identification: Identify each item with attributes listed.
    1) Wires: Wire number and color. Cable number if part of multiconductor cable.
    2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
    3) Components:
        a) Tag number, terminal numbers, and location (“FIELD”, enclosure number, or MCC number).
        b) Switching action (open or close on rising or falling process variable), set point value and units, and process variable description (for example, Sump Level High).
    4) I/O Points: PLC unit number, I/O tag number, I/O address, terminal numbers, and terminal strip numbers.
    5) Relay Coils:
        a) Tag number and its function.
        b) On right side of run where coil is located, list contact location by ladder number and sheet number. Underline normally closed contacts.
    6) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
    7) Communications and Networks: Network type, address or node identification, port or channel number, and type of connector.
f. Show each circuit individually. No “typical” diagrams or “typical” wire lists will be allowed.
g. Ground wires, surge protectors, and connections.
h. Wire and Cable Names: Show names and wire color for circuits entering and leaving a panel.

3. Loop Wiring Diagrams: Individual, end-to-end wiring diagram for each analog and discrete or equipment loop showing all internal panel wiring and connections as well as external wiring and connections. Include all devices and connections from PLC IO terminals to final field elements. Include power wiring as needed:
    a. Conform to the minimum requirements of ISA S5.4.
    b. Under Paragraph 5.3 of ISA S5.4, include the information listed under Subparagraphs 2 and 6.

c. Show loop components within a panel and identify each component, component terminals, and panel terminals.
d. If a loop connects to panels or devices not provided under Section 40_90_00, Instrumentation and Control for Process Systems, and its subsections, such as control valves, motor control centers, package system panels, variable speed drives, include the following information:
    1) Show the first component connected to within the panel or device that is not provided under Section 40_90_00, Instrumentation and Control for Process Systems, and its subsections.
    2) Identify the component by tag and description.
    3) Identify panel and component terminal numbers.
e. Divide each loop diagram into areas for panel face, back-of-panel, field and PLC.
f. Show:
    1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
    2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
    3) Tabular summary on each analog loop diagram:
        a) Transmitting Instruments: Output capability.
        b) Receiving Instruments: Input impedance.
        c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
        d) Total loop impedance.
        e) Reserve output capacity.
    4) Circuit and raceway schedule names.

4. Interconnecting Wiring Diagrams:
    a. Diagrams, device designations, and symbols in accordance with NEMA ICS 1.
    b. Diagrams shall bear electrical subcontractor’s mark showing that they have been coordinated.
    c. Show:
        1) Electrical connections between equipment, consoles, panels, terminal junction boxes, and field mounted components.
        2) Component and panel terminal board identification numbers, and external wire and cable numbers.
        3) Circuit names.
        4) Intermediate terminations between field elements and panels for, but not limited to terminal junction boxes.
        5) Pull boxes.
5. PLC I/O List:
    a. Managed by PIC System Integrator:
        1) During construction PIC System Integrator will maintain PLC I/O List and update the First Stage submitted electronic Microsoft Excel copies to Process Control Consultant.
        2) PIC System Integrator will assign PLC I/O points to specific chassis, slot, and point addresses.

b. PLC I/O List Changes: Changes to PLC I/O List reflecting actual equipment and instrumentation provided.
    1) Mark up electronic file of latest PLC I/O List. Highlight changed cells with yellow, new rows with red, and rows to be deleted with green and provide to Process Control Consultant.
    2) Submit marked up copies changes at 30-day intervals.

6. PLC Hardware Submittals:
    a. Block Diagram: A diagram showing all major PLC's components. Identify components by manufacturer and model number. Show interconnecting cables diagrammatically.
    b. Descriptive Information: Catalog information, descriptive literature, performance specifications, internal wiring diagrams, power and grounding requirements, power consumption, and heat dissipation of all PLC's components. Clearly mark all options and features proposed for this Project.
7. Applications Software Documentation: For equipment for which Process Control Consultant does not provide applications software, provide:
    a. Complete configuration documentation for microprocessor based programmable devices.
    b. For each device, include program listings and function block diagrams, as appropriate, showing:
        1) Functional blocks or modules used.
        2) Configuration, calibration, and tuning parameters.
        3) Descriptive annotations.
    c. Refer to PIC subsections for additional requirements.
        1) Draft Graphics
            a) Screen captures
            b) Native programming files
        2) Draft PLC code
            a) Native Programming files
8. Communications and Digital Networks Diagrams:
    a. Scope: Includes connections to Ethernet network, remote I/O, and field bus (for example, Modbus, Profibus, Foundation Fieldbus, Device Net, etc.).
    b. Format: Network schematic diagrams for each different type of network.
    c. Show:
        1) Interconnected devices, both passive and active.
        2) Device names and numbers.
        3) Terminal numbers.
        4) Communication Media: Type of cable.
        5) Connection Type: Type of connector.
        6) Node and device address numbers.
        7) Wire and cable numbers and colors.
9. Ethernet Network Switch Configuration: Complete list of settings, parameters, and configuration details.
10. Panel Power Requirements and Heat Dissipation: For control panels tabulate and summarize:
    a. Required voltages, currents, and phases(s).
    b. Maximum heat dissipations Btu per hour.
    c. Calculations.

d. Steady State Temperature Calculations: For panels, provide heat load calculations showing the panel estimated internal steady state temperature.

11. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for:
    a. Pipes and Tubes: Thickness, pressure rating, and materials.
    b. Components: Valves, regulators, and filters.
    c. Connections to panel-mounted devices.
    d. Panel interface connections.
    e. Submit electronic copies of Drawings.
12. Installation Details: Include modifications or further details required and define installation of I&C components.
13. Spares, expendables, and test equipment.
    a. Electronic Copies: Microsoft Excel.
14. Shop Drawings for Changes Impacting PLC and SCADA Programming:
    a. Submit details of changes required to PLC and SLDC monitoring and control resulting from installation of alternative or upgraded process equipment and instrumentation, and other causes.
    b. Submit changes at 30-day intervals.
15. Color schedule for control panels.

D. Third Stage Submittals:
    1. PICS Portion of Schedule of Values: Incorporate proposed Submittal breakdown.
    2. PICS Portion of Progress Schedule:
        a. Upon acceptance by Engineer, incorporate in Contractor's Detailed Progress Schedule specified in Section 01_32_21, Schedules and Reports.
        b. Incorporate proposed Submittal breakdown.
    3. Operation and Maintenance Data: In accordance with Section 01_78_24, Operation and Maintenance Manuals, and in addition the following:
        a. General:
            1) Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for PIC components.
            2) Submittal Format: Both hard copy and electronic copies for all submittals. Operation and Maintenance manuals shall be submitted as an indexed PDF as well as hard copies as specified by the Engineer and/or Owner.
        b. Final versions of Legend and Abbreviation Lists.
        c. Process and Instrumentation Diagrams: Marked up copy of revised P&ID to reflect as-built PIC design.
        d. Provide the following items as defined under heading First and Second Stage Submittals:
            1) Bill of materials.
            2) Catalog cuts.
            3) Instrument list.
            4) Component data sheets.
            5) Detailed Wiring Diagrams:
                a) Panel wiring diagrams.
                b) Loop diagrams.

c) Interconnecting wiring diagrams.
d) If field-wiring modifications are made after these drawings are submitted, the affected drawings shall be revised and resubmitted.

6) Panel plumbing diagrams.
7) Final I/O List with all fields populated.
8) Final Control Narratives.
9) Final Graphics.
10) Final OIT Graphics.
11) Applications software documentation.

e. If any changes are made after the submittal; the affected information will be revised and resubmitted.
f. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices:
1) Content for Each O&M Manual:
a) Table of Contents.
b) Operations procedures.
c) Installation requirements and procedures.
d) Maintenance requirements and procedures.
e) Troubleshooting procedures.
f) Calibration procedures.
g) Internal schematic and wiring diagrams.
h) Component and I/O Module Calibration Sheets from field quality control calibrations.

2) Provide PDF file with linked index to all manuals.
3) When instruction booklets cover more than one specific model or range of device, product data sheets shall be included that indicate the device model number and other special features.

g. Provide a tabular summary of all maintenance and calibration activities that are recommended for periodic execution. Include recommended intervals in the tabular summary.
h. List of spares, expendables, test equipment and tools provided.
i. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.

4. Testing Related Submittals:
a. Preliminary Test Procedures:
1) Outline of proposed tests, forms, and checklists.
2) Combined submittal to include Staging Site Demonstration Test, Factory Demonstration Test, and Functional Test Part 1.

b. Final Test Procedures:
1) Proposed test procedures, forms, and checklists.
2) Combined submittal to include Staging Site Demonstration Test, Factory Demonstration Test, and Functional Test Part 1.

c. Test Documentation:
1) Copy of signed off test results.
2) Include completed component calibration data sheets from Functional Test.
3) Combined submittal to include Staging Site Demonstration Test, Factory Demonstration Test, and Functional Test Part 1.

5. Owner Training Plan.

## 1.06 QUALITY ASSURANCE

A. PIC Coordination Meetings:
   1. General: Refer to Section 01_31_19, Project Meetings, for PIC coordination meetings.
   2. Quantity: Provide for a minimum of 6 meetings.
   3. Specific Meetings:
      a. PIC Schedule Coordination Meeting:
         1) Timing: Following Engineer review of PIC Progress Schedule.
         2) Purpose: Discuss Engineer's comments and resolve scheduling issues.
      b. Startup and Training:
         1) Timing: Following Engineer review of preliminary training plan and prior to Functional Test.
         2) Purpose:
            a) Startup and testing planning.
            b) Resolve required changes to proposed training plan.
            c) Identify specific Owner personnel to attend training.

## 1.07 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01_60_00, Product Requirements.

B. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.

C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.

D. Cover panels and other elements that are exposed to dusty construction environments.

## 1.08 SEQUENCING AND SCHEDULING

A. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times listed below have been completed and satisfied:
   1. PICS Kickoff Meeting Prerequisite: Schedule of Values and Progress Schedule submitted.
   2. Shop Drawing Reviews by Engineer:
      a. Prerequisite: Engineer acceptance of Schedule of Values and Progress Schedule.
      b. Schedule: In accordance with completed schedule of Shop Drawing and Sample submittals specified in Section 01_33_00, Submittal Procedures.
   3. Test Prerequisite: Associated test procedures submittals completed.
   4. Equipment Delivered to Staging Site: Refer to test description for a definition of this equipment.
      a. Prerequisites:
         1) Approval of associated PIC Shop Drawings.
         2) Approval of related testing procedures.

5. PLC and HMI Applications Software Configuring and Testing by Process Control Consultant:
    a. Prerequisite: Staging site demonstration test completed.
    b. Duration: 150 days.
6. Shipment of Staging site demonstration test equipment to jobsite:
    a. Prerequisite: PLC and HMI Application Software Configuration completed.
7. FDT Equipment Shipment to Site:
    a. General Prerequisites:
        1) Approval of PIC Shop Drawings and preliminary operation and maintenance data.
        2) FDT completed.
8. PICS Startup and Testing Meeting Prerequisite: Factory Demonstration Test and Staging Site Demonstration Test Complete.
9. Functional Test Part 1:
    a. Prerequisites:
        1) PICS Startup and Testing Meeting complete.
        2) PLC and HMI installation complete.
10. Functional Test Part 2 Prerequisite: Functional Test Part 1 completed.
11. Performance Test Prerequisite: Functional Test Part 2 completed and facility started up.
12. Performance Test Prerequisite: Functional Test completed and facility started up.
13. Training Prerequisite: Associated training plan Submittal completed.

## 1.09 PARTIAL PAYMENT LIMTS

A. Payment acceptable completion of activity.

B. Limits:
1. Administrative and Shop Drawing Submittals: 20 percent, maximum.
2. Factory Demonstration Test: 5 percent, minimum.
3. Staging Site Demonstration Test: 5 percent, minimum.
4. Functional Test Part 2: 10 percent, minimum.
5. PICS O&M Manuals: 3 percent, minimum.

## 1.10 EXTRA MATERIALS

A. As specified in PIC subsections plus as follows:

| Description | Percent of Each Type and Size Used | No Less Than |
|---|---|---|
| dc power supplies | 20 | 1 |
| Surge Suppressors | 10 | 2 |

B. In computing spare parts quantities based on specified percentages, round up to nearest whole number.

C. Expendables: For following items provide manufacturer's recommended 2-year supply, unless otherwise noted.
   1. Chemical for analyzers.

## 1.11 SPARE PARTS

A. The following spare parts shall be provided:
   1. One (1) spare uninstalled PLC processors.
   2. One (1) spare communications module of each type used.
   3. One (1) spare remote I/O module.
   4. One (1) spare fiber optic module.
   5. One (1) Fiber optic modems module of each type.
   6. One (1) spare rack of each type used.
   7. One (1) spare power supply of each type used.
   8. Two (2) spare PLC input/output cards of each type used.
   9. Six (6) spare power fuses of each type used.
   10. Ten (10) spare control/analog fuses of each type used.
   11. Any other items not included from the Manufacturer's recommended spare parts list.

B. The following expendable products shall be provided:
   1. Items with limited shelf-life shall be provided over the year as needed.
   2. One (1) year supply of items recommended by the Manufacturer of the equipment for each component.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. Provide PIC functions shown on Drawings and required in PIC subsections for each system and loop. Furnish equipment items required in PIC subsections. Furnish materials, equipment, and software whether indicated or not, necessary to effect required system and loop performance.

B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment, materials, and software.
   1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with the General Conditions, Article 6.05 Substitutes and "Or-Equals."
   2. If proposed item requires, but not limited to, different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories, provide such equipment and work.

C. Like Equipment Items:
   1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
   2. Implement same or similar functions in same or similar manner. For example control logic, sequence controls, and display layouts.

## 2.02 I&C COMPONENTS

A. Specifications: Refer to Section 40_91_00, Instrumentation and Control Components, for specifications for I&C components.

B. Components for Each Loop: Major components for each loop are listed in Instrument List referenced in Article Supplements. Furnish equipment that is necessary to achieve required loop performance.

C. Control Panels: Reference Control Panel Schedule in Article Supplements.

## 2.03 PLC I/O

A. Physical I/O points are shown on P&ID drawings. Provide any additional I/O, functions or operations required to provide a completely operational system. Note that this list does not show the PLCs diagnostic fault detection points which are required. In cases of conflict between Instrumentation Loop Diagrams and the PLC I/O lists, P&IDs and Instrumentation Loop Diagrams take precedence.

B. Spare I/O:
   1. Provide each PLC with at least 20 percent installed spare I/O points for each type of I/O used by that PLC.
   2. Use the actual I/O for this Project in calculating the installed spare I/O quantities.
   3. Wire all spare I/O to terminal blocks and, where required, surge suppressors so that it is ready for field termination.

C. Spare Slots:
   1. Provide spare slots for future equipment to be accommodated by each panel. Use the future I/O module counts listed in the PLC Component List in the supplements of this section.
   2. In addition to the spare slots for future equipment, provide 20 percent additional spare slots. Base the number provided on the total of the modules being installed for this Project (including installed spare modules) plus those being provided for future equipment.
   3. Use the highest module capacity PLC chassis available. If the number of slots required exceeds the module capacity provided by using the highest capacity chassis available, provide subpanel space and wireway only for required future chassis.

D. Separate Input and Output Modules for Parallel Controlled Modules: Unless otherwise noted or shown, provide separate discrete and analog input and output modules for parallel controlled equipment. For instance if there are a total of three pumps in a pump station, provide two sets of input and output modules. Wire two pumps to one module and the third to a second module.

E. Cables: Provide all cables for interconnecting PLC components both inside individual panels and between panels or remote devices.

## 2.04 FIELD BUS, NETWORK, AND HMI COMPONENTS

A. Reference Computer and Network Equipment Lists in Article, Supplements, and computer and network components in Section 40_91_00, Instrumentation and Control Components.

## 2.05 SERVICE CONDITIONS

A. Standard Service Conditions: The following defines certain types of environments. PIC subsections refer to these definitions by name to specify the service conditions for individual equipment units. Design equipment for continuous operation in these environments:
   1. Control Room and IT Closet:
      a. Temperature: 70 degrees Fahrenheit to 85 degrees Fahrenheit.
      b. NEC Classification: Nonhazardous.
   2. Electrical Rooms:
      a. Temperature: 60 degrees Fahrenheit to 85 degrees Fahrenheit.
      b. NEC Classification: Nonhazardous.
   3. Inside:
      a. Temperature: 35 to 100 degrees Fahrenheit.
      b. Relative Humidity: 10 percent to 100 percent.
      c. NEC Classification: Nonhazardous.
   4. Outside:
      a. Temperature: 0 to 100 degrees Fahrenheit.
      b. Relative Humidity10 percent to 100 percent, rain.
      c. NEC Classification: Nonhazardous.

## 2.06 NAMEPLATES AND TAGS

A. Panel Nameplates: Enclosure identification located on enclosure face.
   1. Location and Inscription: Refer to Control Panel Schedule.
   2. Materials: Laminated plastic attached to panel with stainless steel screws.
   3. Letters: 1/2-inch high, white on black background, unless otherwise noted.

B. Component Nameplates, Panel Face: Component identification located on panel face under or near component.
   1. Location and Inscription: As shown on panel drawing.
   2. Materials: Adhesive-backed, laminated plastic.
   3. Letters: 3/16-inch high, white on black background, unless otherwise noted.

C. Component Nameplates, Back of Panel: Component identification located on or near component inside of enclosure.
   1. Inscription: Component tag number.
   2. Materials: Adhesive-backed, laminated plastic.
   3. Letters: 3/16-inch high, white on black background, unless otherwise noted.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.
   1. Inscription:
      a. Refer to table under Paragraph Standard Pushbutton Colors and Inscriptions.
      b. Refer to table under Paragraph Standard Light Colors and Inscriptions.

c. Refer to P&IDs on Drawings.

2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
3. Letters: Black on gray or white background.

E. Service Legends: Component identification nameplate located on face of component.
1. Inscription: As shown on panel drawing.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch high, white on black background, unless otherwise noted.

F. Safety Nameplates:
1. As required by applicable codes and standards including NFPA 79 and UL 508A.
2. Provide a warning nameplate on all control panel enclosures with circuits from more than one electrical supply. For example, any panel with dry contacts in a circuit powered elsewhere.

G. Nametags: Component identification for field devices.
1. Inscription: Component tag number.
2. Materials: 16-gauge, Type 304 stainless steel.
3. Letters: 3/16-inch high, imposed.
4. Mounting: Affix to component with 16-guage or 18-gauge stainless steel wire or stainless steel screws.

## 2.07 MECHANICAL SYSTEM COMPONENTS

A. Reference Section 40_91_00, Instrumentation and Control Components.

## 2.08 FUNCTIONAL REQUIREMENTS FOR CONTROL LOOPS

A. Shown on Drawings, in panel control diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on Drawings.

B. Supplemented by Loop Specifications that describe requirements not obvious on P&IDs or panel control diagrams.

C. Supplemented by standard functional requirements in PIC subsections.

## 2.09 LOOP SPECIFICATIONS

A. See Article Supplements located at End of Section.

## 2.10 ELECTRICAL REQUIREMENTS

A. Control panels to only be powered by 120-volt alternating current (VAC) circuits. Voltages above 240 VAC shall be located in a separate enclosure.

B. The use of 120 VAC circuits should be minimized and 24-volt direct current (VDC) power and devices should be used when possible.

C. All equipment required to communicate to the SCADA system that a station has a power failure has occurred will have back-up power.

D. Electrical Raceways: As specified in Section 26_05_33, Raceway and Boxes.

E. Wiring External to PIC Equipment:
   1. Special Control and Communications Cable: Provided by PIC System Integrator as noted in Component Specifications and PIC subsections.
   2. Other Wiring and Cable: As specified in Section 26_05_05, Conductors.

F. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

G. Wires within Enclosures:
   1. AC Circuits:
      a. Type: 600-volt, Type MTW stranded copper.
      b. Size: For current to be carried, but not less than No. 18 AWG.
   2. Analog Signal Circuits:
      a. Type: 600-volt stranded copper, twisted shielded pairs or triad with a 100 percent, aluminum-polyester shield, rated 60 degrees Celsius.
      b. Panels with Circuits Less Than 600 volts: Rated at 600 volts. Belden No. 18 AWG Type 9341, Triad Beldon No. 1121A.
      c. Size: No. 18 AWG, minimum.
      d. Each signal protected with surge protection.
      e. Each signal protected with a fuse on the power supply wire.
      f. Shields to be connected to ground at PLC panel only.
      g. Analog Signal Isolators: Furnish signal isolation for analog signals that are sent from one enclosure to another. Do not wire in series instruments on different panels, cabinets, or enclosures.
   3. Other dc Circuits.
      a. Type: 600-volt, Type MTW stranded copper.
      b. Size: For current carried, but not less than No. 18 AWG.
   4. Special Signal Circuits: Use manufacturer's standard cables.
   5. Wire Identification: Numbered and tagged at each termination.
      a. Wire Tags: Laser/ink jet self-laminating label, 0.50-inch width by 0.75-inch length, 18 - 14 AWG, white print-on area, polyester, clear/white.
      b. Label to match panel drawings.
      c. Manufacturers:
         1) Brady Perma Sleev.
         2) Tyco Electronics.

H. Terminate and identify wires entering or leaving enclosures as follows:
   1. Analog and discrete signal, terminate at numbered terminal blocks.
   2. Special signals terminated using manufacturer's standard connectors.
   3. Identify wiring in accordance with requirements in Section 26_05_05, Conductors.

I. Terminal Blocks for Enclosures:
   1. All terminal blocks shall be single layer terminal blocks with screw clamp connectors and no more than two wires per terminal shall be wired.

2. Quantity:
    a. Accommodate present and spare indicated needs.
    b. Wire spare PLC I/O points to terminal blocks.
    c. One wire per terminal for field wires entering enclosures.
    d. One wire per terminal for wires greater than 18 AWG for internal enclosure wiring.
    e. Maximum of two wires per terminal for No. 18 AWG wire for internal enclosure wiring.
    f. Spare Terminals: 20 percent of connected terminals, but not less than 10 per terminal block, unless otherwise shown on Drawings.
3. Terminal Block Types: Reference Section 40_91_00, Instrumentation and Control Components, Part 2, Article Electrical Components.
4. Mounting:
    a. Standard DIN rail.
    b. Terminal block can be extracted from an assembly without displacing adjacent blocks.
    c. End Stops: Minimum of one at each end of rail.
5. Terminal blocks shall be single level only.
6. Jumpers: Allow jumper installation without loss of space on terminal or rail. Jumpers to be installed on top of terminal and should not be inserted into the wiring connectors.

J. Grounding of Enclosures:
1. Furnish isolated copper grounding bus for signal and shield ground connections.
2. Ground this ground bus at a common signal ground point in accordance with National Electrical Code requirements.
3. Single Point Ground for Each Analog Loop:
    a. Locate signal ground at dc power supply for loop.
    b. Use to ground wire shields for loop.
4. Ground terminal block rails to ground bus.

K. Analog Signal Isolators:
1. Furnish signal isolation for analog signals that are sent from one enclosure to another.
2. Do not wire in series instruments on different panels, cabinets, or enclosures.

L. Intrinsic Safety System Installation:
1. Comply with NEC Article 504, Intrinsically Safe Systems.
2. Install intrinsically safe circuits in a separate wire way that:
    a. Is separated from nonintrinsically safe circuits as specified by NEC.
    b. Is colored light blue and has message “Intrinsically Safe Circuits Only” on raceway cover every 6 inches.

M. Wiring Interface: Terminate and identify wiring entering or leaving enclosures.
1. Analog and Discrete Signal Wires: Terminate at numbered terminal blocks as shown on the wiring diagrams.
2. Wiring for Special Signals: Terminate communications, digital data, and multiplexed signals using manufacturer’s standard connectors for the device to which the signals terminate.

N. Electrical Transient Protection:
    1. General:
        a. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
        b. Surge suppressors are not shown for external analog transmitters. Determine quantity and location, and show in Shop Drawings. Refer to example wiring in installation details in Drawings.
        c. Provide, install, coordinate, and inspect grounding of surge suppressors at:
            1) Connection of ac power to PIC equipment including panels, consoles assembles, and field-mounted analog transmitters and receivers.
            2) At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.
    2. Recovery: Automatic.
    3. Surge Suppressor Types: Reference Section 40_91_00, Instrumentation and Control Components, Part 2, Surge Suppressors.
    4. Installation and Grounding of Suppressors:
        a. As shown. See Surge Suppressor Installation Details
            1) At point of connection between an equipment item, including AC powered transmitters, and power supply conductor (direct-wired equipment).
            2) Analog Wires: At each end of all analog input (AI) and analog output (AO) where any part of the wire travel outside of building.
            3) Discrete Wires: At PLC end where any part of the wire travel outside of building.
            4) In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.
        b. Grounding equipment: installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.
        c. All wires terminating or passing through outside spaces or panels shall be protected with surge protection inside the panel.

## 2.11 PANEL FABRICATION

A. General:
    1. Nominal Panel Dimensions: Refer to Control Panel Schedule in Article Supplements for maximum external dimensions allowed for individual control panels.
    2. Panel Component Schedule: Refer to Control Panel Schedule in Article Supplements which provides a list by local control panel of major panel-mounted components for each panel. In case of a conflict between this list and Instrument List, Instrument List takes precedence. In case of a conflict between Panel Component Schedule and P&IDs, P&IDs take precedence.
    3. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), state and local codes, and applicable sections of NEMA, ANSI, UL, and ICECA.

4. Fabricate panels, install instruments and wire, and plumb at PIC System Integrator's facility. No fabrication other than correction of minor defects or minor transit damage permitted onsite.
5. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.
6. For panels with more than one source of power include mark stating: "CAUTION: This panel contains multiple sources of power."
7. Electrical Work: In accordance with the applicable requirements of Division 26, Electrical.
8. General Layout:
    a. PLC located at top of panel

B. Outdoor/Wet Panels:
1. Outdoor panels shall be oriented to minimize a direct sunlight on the front.
2. All panel entries shall be at the bottom using water tight conduit fittings/Meyers hubs or approved equal.

C. Temperature Control:
1. Nonventilated Panels: Design to adequately dissipate heat from equipment mounted inside panel and on panel.
2. Ventilated Panels:
    1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel and on panel.
    2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
    3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
    4) Louver Construction: Stamped sheet metal.
    5) Ventilation Fans:
        a) Furnish where required to provide adequate cooling.
        b) Create positive internal pressure within panel.
        c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
    6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
3. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation.
4. Space Heaters:
    a. Controlled by thermostat to maintain temperature above 40 degrees Fahrenheit.
    b. Refer to Control Panel Schedule in Article Supplements.

D. Freestanding Panel Construction:
1. Materials:
    a. Sheet steel, unless otherwise noted in Control Panel Schedule in Article Supplements.
    b. Minimum Thickness: 10-gauge, unless otherwise noted.
2. Panel Front:
    a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
    b. No seams or bolt heads visible when viewed from front.
    c. Panel Cutouts: Smoothly finished with rounded edges.

d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.

3. Internal Framework:
   a. Structural steel for instrument support and panel bracing.
   b. Permit panel lifting without racking or distortion.
4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.
5. Adjacent Panels: Securely bolted together so front faces are parallel.
6. Door:
   a. Full height, fully gasketed access door where shown on Drawings.
   b. Latch: Three-point, with single lever-type lockable handle operation to open door.
   c. Hinges: Full-length, continuous, piano-type, steel hinges with stainless steel pins.
   d. Rear Access: Extend no further than 24 inches beyond panel when opened to 90-degree position.

E. Nonfreestanding Panel Construction:
   1. Based on environmental design requirements and referenced in Article Environmental Requirements, provide the following unless otherwise noted in Control Panel Schedule in Article Supplements:
      a. Panels listed as inside, air conditioned:
         1) Enclosure Type: NEMA 12.
         2) Materials: Steel.
      b. Other Panels:
         1) Enclosure Type: NEMA 4X.
         2) Materials: Type 316 stainless steel.
   2. Metal Thickness: 14-gauge, minimum.
   3. Doors:
      a. Rubber-gasketed with continuous hinge.
      b. Stainless steel lockable quick-release clamps.
   4. Manufacturers:
      a. Hoffman Engineering Co.
      b. H. F. Cox.

F. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels:
   1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

G. Control Panel Electrical:
   1. Control panels which contain voltages above 240V shall have a separation between lower and higher voltage sections. The section with voltages higher than 120V shall be enclosed and protected with a deadfront panel.
   2. PLC/Control Panels:
      a. Provide panels with 120 VAC uninterruptible power supply (UPS), 24 VDC battery backup or UPS circuit from plant UPS system. Backup power should include a minimum 10-minute back-up power for a fully loaded control panel. Features of a UPS will include:
         1) All components other than auxiliary 120 VAC circuits shall be powered from the UPS.
            a) Auxiliary circuits include:
               (1) Panel 120VAC service outlets.

(2) Panel heaters.
(3) Panel AC.

2) Quick disconnect feature of UPS to allow UPS to be easily removed and installed.
a) Pigtail connections.
b) Removable terminal blocks.
3) Provide hard wired alarm contact for Fault, On Battery, and Low Battery from UPS.
4) All equipment that is required to communicate to the SCADA system that a station power failure has occurred, shall be powered from the UPS.

b. Provide temperature probe to measure the internal panel temperature and wire to PLC analog input.
c. All digital inputs (DI) to be individually fused on the power supply wire with a fused terminal block.
d. All digital outputs (DO) shall use interposing relays.
e. All Analog inputs (AI) to be individually fused on the power supply wire with a fused terminal block.
f. All spare I/O to be wired to appropriate terminal blocks.
1) For Spare DI and spare AI wire half with surge.
2) For spare AI wire half as 2 wire and half as 4 wire.
3) For spare DO wire to interposing relays.
g. All IO where any portion of the circuit is outside a building envelop shall be protected with appropriate surge suppressors.

3. Power Distribution within Panels:
a. Circuit Breakers: Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
b. Feeder Circuits:
1) One or more 120V ac, 60-Hz feeder circuits as shown on Drawings.
2) Make provisions for feeder circuit conduit entry.
3) Furnish terminal block for termination of wires.
c. Power Panel: Furnish main circuit breaker and circuit breaker on each individual branch circuit distributed from power panel.
1) Locate to provide clear view of and access to breakers when door is open.
2) Breaker Sizes: Coordinate such that fault in branch circuit will blow only branch breaker, but not trip main breaker.
a) Branch Circuit Breakers: 15 amps at 250V ac.
3) Breaker Manufacturers and Products: Refer to Division 26, Electrical.
d. Circuit Wiring: P&IDs and Control Diagrams on Drawings show function only. Use following rules for actual circuit wiring:
1) Devices on Single Circuit: 20, maximum.
2) Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
3) Branch Circuit Loading: 12 amperes continuous, maximum.
4) Provide individual branch circuit breakers for the following equipment at a minimum:
a) PLC Power Supply.
b) HMI Power supply.
c) Individual network equipment.

5) Panel Lighting and Service Outlets: Put on separate 15 amp, 120V ac branch circuit.
6) Provide 120V ac plugmold for panel components with line cords.

4. Signal Distribution:
   a. Signal Wiring: Separate analog signal cables from power and control within a panel and cross at right angles where necessary.
   b. Any nonenergized (“Cold”) spare conductors to or from other locations to be cleanly coiled and clearly labeled at both ends. Any energized (“Hot”) spare conductors to be terminated on terminal blocks.
   c. Wire PLC output points to relay and relay to terminal blocks. No field wiring to be landed directly on relay base.
   d. Within Panels: 4 to 20 mA dc signals may be distributed as 1V dc to 5V dc.
   e. Outside Panels: Isolated 4 to 20 mA dc only.
   f. Signal Wiring: Twisted shielded pairs.
   g. RTD and Thermocouple Extension Cable:
      1) Continuous field to panel with no intermediate junction boxes or terminations.
      2) RTDs in motor windings are considered a 600-volt circuit.
      3) Terminate thermocouple extension wire directly to loop instrument.
5. Signal Switching:
   a. Use dry circuit type relays or switches.
   b. No interruption of 4 to 20 mA loops during switching.
   c. Switching Transients in Associated Signal Circuit:
      1) 4 to 20 mA dc Signals: 0.2 mA, maximum.
      2) 1V dc to 5V dc Signals: 0.05V, maximum.
6. Relay Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Article Electrical Components.
   a. Provide UL-listed relay or relay and socket combination.
      1) Relay Mounting: Plug-in type socket.
      2) Type: Dry circuit.
      3) Coil Voltage: 24 VDC unless otherwise noted.
      4) Contact Arrangement: 2 Form C contacts.
      5) Indication Type: LED indicator lamp.
      6) Socket Mounting: Din Rai.
7. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.
8. Internal Panel Lights for Freestanding Panels:
   a. Type: Switched LED lights.
   b. Quantity: One light for every 4 feet of panel width.
   c. Mounting: Inside and in the top of back-of-panel area.
   d. Protective metal shield for lights.
   e. Activated via intrusion switch.
9. Service Outlets for Freestanding Panels:
   a. Type: Three-wire, 120-volt, 15-ampere, GFCI duplex receptacles.
   b. Not connected to panel UPS power.
   c. Quantity:
      1) Panels 4 Feet Wide and Smaller: One.
      2) Panels Larger than 4 Feet Wide: One for every 4 feet of panel width, two minimum per panel.
   d. Mounting: Evenly spaced along back-of-panel area.

10. Internal Panel Lights and Service Outlets for Smaller Panels:
    a. Internal Panel Light: Switched LED lights.
    b. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle:
    c. Required for panels. Refer to Control Panel Schedule in Article Supplements.
11. Standard Pushbutton and Selector Switch Colors and Inscriptions:
    a. Use following unless otherwise noted in Instrument List:

| **Inscription(s)** | **Button Color** |
|---|---|
| ON<br>OFF | Black<br>Black |
| OPEN<br>CLOSE | Black<br>Black |
| OPEN<br>CLOSE<br>AUTO | Black<br>Black<br>Black |
| ON<br>OFF<br>AUTO | Black<br>Black<br>Black |
| MANUAL<br>AUTO | Black<br>Black |
| START<br>STOP | Black<br>Black |
| RESET | Black |

    b. Lettering Color:
        1) Tag Plate Lettering Color: White lettering on black background.
        2) Black on white and yellow buttons.
        3) White on black, red, and green buttons.
12. Standard Light Colors and Inscriptions:
    a. Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted. In all cases the LED bulb shall be clear.

| **Inscription(s)** | **Lens Color** |
|---|---|
| ON | Red |
| OFF | Green |
| OPEN | Red |
| CLOSED | Green |
| LOW | Amber |
| FAIL | Amber |
| HIGH | Amber |

| Inscription(s) | Lens Color |
|---|---|
| AUTO | White |
| MANUAL | Yellow |
| LOCAL | White |
| REMOTE | Yellow |
| Alarms | Amber |
| AC POWER | White |

b. Lettering Color: White lettering on black background.

13. Standard Pushbuttons and LEDs:
    a. Push to test type LEDs.
    b. LEDs to be installed in LED base, LED bulbs in incandescent bases shall not be used.

H. PIC Enclosure Internal Wiring:
1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Provide abrasion protection for wire bundles that pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
    a. Locking-fork-tongue or ring-tongue lugs.
    b. Use manufacturer's recommended tool with required sized anvil to make crimp lug terminations.
    c. Wires terminated in a crimp lug, maximum of one.
    d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
    a. Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.
    b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V DC and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
11. Plastic Wire Duct Fill: Do not exceed manufacturer's recommendations.
12. Conductors Carrying Foreign Voltages within a Panel:
    a. Route foreign voltage conductors into panel and land on a circuit blade disconnect type terminal block.
    b. Use wire with yellow insulation to identify foreign voltage circuits within panel from terminal block on. Do not use wires with this yellow insulation for any other purpose.

13. Harness Wiring:
    a. 120V AC: No. 14 AWG, MTW.
    b. 24V DC: No. 16 AWG, MTW where individual conductors are used and Type TC shielded tray cable where shielded wire is used.
14. Panelwork:
    a. No exposed connections.
    b. Allow adjustments to equipment to be made without exposing these terminals.
    c. For power and control wiring operating above 80V ac or dc use covered channels or EMT raceways separate from low voltage signal circuits.
15. Plastic Wire Ducts Color:
    a. 120V AC: White.
    b. 24V DC: Gray.
    c. Communications Cables and Fiber Optic Jumpers: Orange.
16. Provide a communications plastic wire duct for communications cables and fiber optic cables between the communications devices in control panel and communications raceways. Design plastic wire duct design to take into account the minimum bending radius of the communications cable.
17. Make plastic wire ducts the same depth.
18. Provide a minimum of 2 inches between plastic wire ducts and terminal blocks.
19. If 2 inches of space are not available, provide as much space as possible to field wiring.
20. Wire labels installed 1 inch from connection point.
21. Use standoffs to raise terminals if needed to facilitate ease of field wiring.

I. Control Relay Arrangement: Install control relays associated with specific loops in same panel section as corresponding terminal blocks or side panels. One relay for each digital output (both used and spare) minimum. Provide 20 percent space for future relays. Locate spare space in same sections as spare terminal blocks.

J. Factory Finishing:
    1. Furnish materials and equipment with manufacturer's standard finish system in accordance with Section 09_96_01 High Performance Coatings.
    2. Use specific color if indicated. Otherwise use manufacturer's standard finish color, or light gray if manufacturer has no standard color.
    3. Stainless Steel and Aluminum: Not painted.
    4. Nonmetallic Panels: Not painted.
    5. Steel Panels:
        a. Sand panel and remove mill scale, rust, grease, and oil.
        b. Fill imperfections and sand smooth.
        c. Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
        d. Sand surfaces lightly between coats.
        e. Dry Film Thickness: 3 mils, minimum.
        f. Color: Manufacturer's standard.

K. Panel Drawings and Documentation:
   1. All panels will be provided with the following drawings and documentation, unless otherwise noted. All files to be in FKAA-approved electric file format (ACAD version XX and PDF) and should be easily readable when printed on 11x17 paper:
      a. Panel fabrication drawings. Dimensional layout drawn to scale in inches. This should show all components as well as the spacing between components. Provide enough detail that reviewers can verify proper component spacing requirements. Specific dimensions to include the following as a minimum:
         1) Outside panel dimensions.
         2) Space between PLC components and closest adjacent component (Panel wall, Panduit, terminal block, etc).
         3) Space between terminal blocks and Panduit or panel wall.
      b. Bill of Material showing each component part number or ordering information. This information should be on drawings as well as in Excel.
      c. Electrical drawings showing all components of the panel. Drawing should identify the following:
         1) Terminal numbers.
         2) Wire labels.
         3) Component identification labels.
         4) Terminal block group identifications.
         5) Wire color code legend.
         6) Terminal symbol legend.
      d. Communication drawings containing the following:
         1) All communication equipment.
         2) All Ethernet-connected devices.
         3) Fiber connection between devices/buildings.
         4) Other non-Ethernet connected devices (such as serial).
      e. I/O List in excel format:
         1) Obtain sample IO list from Owner.
         2) Where possible like equipment should be placed on separate IO modules to prevent a single card failure from stopping a process.
      f. Loop drawings showing the complete circuit from the field device to the I/O card with each wire, terminal and termination location identified.

## 2.12 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsules:
   1. Areas Where Required: Refer to Part 3, Article Protection.
   2. Manufacturers and Products:
      a. Northern Instruments; Model Zerust VC.
      b. Hoffmann Engineering; Model A-HCI.

## 2.13 TEST EQUIPMENT AND TOOLS

| Item | Quantity | Options and Model |
|---|---|---|
| Digital Multimeter | 1 | Fluke Model 787B Process Meter with test leads, removable test probes, long reach alligator clips, magnetic hanger, temperature probe, and carrying case. |

## 2.14 SOURCE QUALITY CONTROL

A. General:
   1. Engineer may actively participate in many of the tests.
   2. Engineer reserves right to test or retest specified functions.
   3. Engineer's decision will be final regarding acceptability and completeness of testing.
   4. Procedures, Forms, and Checklists:
      a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
      b. Describe each test item to be performed.
      c. Have space after each test item description for sign off by appropriate party after satisfactory completion.
   5. Required Test Documentation: Test procedures, forms, and checklists signed by Engineer and Contractor.
   6. Conducting Tests:
      a. Provide special testing materials and equipment.
      b. Wherever possible, perform tests using actual process variables, equipment, and data.
      c. If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
      d. Define simulation techniques in test procedures.
      e. Test Format: Cause and effect.
         1) Person conducting test initiates an input (cause).
         2) Specific test requirement is satisfied if correct result (effect), occurs.
      f. For PIC systems for which Process Control Consultant provides applications software, provide sufficient temporary software configuring to allow FDT and SSDT testing of these subsystems.

## 2.15 MAINTENANCE OF PROGRAMMING EQUIPMENT

A. Provide for maintenance of programming equipment while at Process Control Consultant's office. Repair or replace failed equipment within 2 days of notice by Process Control Consultant.

# PART 3 EXECUTION

## 3.01 EXAMINATION

A. For equipment not provided by PIC System Integrator, but that directly interfaces with PIC, verify the following conditions:
   1. Proper installation.
   2. Calibration and adjustment of positioners and I/P transducers.
   3. Correct control action.
   4. Switch settings and dead bands.
   5. Opening and closing speeds and travel stops.
   6. Input and output signals.

## 3.02 INSTALLATION

A. Material and Equipment Installation: Follow manufacturers' installation instructions, unless otherwise indicated or directed by Engineer.

B. Wiring connected to PIC components and assemblies, including power wiring in accordance with requirements in Section 26_05_05, Conductors.

C. All alarm inputs to the PLC shall be from normally closed contacts when in the normal (not alarm) state.

D. Electrical Raceways: As specified in Section 26_05_33, Raceway and Boxes.

E. Mechanical Systems:
   1. Copper and Stainless Steel Tubing Support: Continuously supported by aluminum tubing raceway system.
   2. Plastic Tubing Support: Except as shown on Drawings, provide continuous support in conduit or by aluminum tubing raceway system.
   3. Install conduit for plastic tubing and tubing raceways parallel with, or at right angles to, structural members of buildings. Make vertical runs straight and plumb.
   4. Tubing and Conduit Bends:
      a. Tool-formed without flattening, and of same radius.
      b. Bend Radius: Equal to or larger than conduit and tubing manufacturer's recommended minimum bend radius.
      c. Slope instrument connection tubing in accordance with installation details.
      d. Do not run liquid filled instrument tubing immediately over or within a 3-foot plan view clearance of electrical panels, motor starters, or mechanical mounting panel without additional protection. Where tubing must be located in these zones, shield electrical device to prevent water access to electrical equipment.
      e. Straighten coiled tubing by unrolling on flat surface. Do not pull to straighten.
      f. Cut tubing square with sharp tubing cutter. Deburr cuts and remove chips. Do not gouge or scratch surface of tubing.
      g. Blow debris from inside of tubing.
      h. Makeup and install fittings in accordance with manufacturer's recommendations. Verify make up of tube fittings with manufacturer's inspection gauge.
      i. Use lubricating compound or TFE tape on stainless steel threads to prevent seizing or galling.
      j. Run tubing to allow but not limited to, clear access to doors, controls and control panels; and to allow for easy removal of equipment.
      k. Provide separate support for components in tubing runs.
      l. Supply expansion loops and use adapters at pipe, valve, or component connections for proper orientation of fitting.
      m. Keep tubing and conduit runs at least 12 inches from hot pipes.
      n. Locate and install tubing raceways in accordance with manufacturer's recommendations. Locate tubing to prevent spillage, overflow, or dirt from above.
      o. Securely attach tubing raceways to building structural members.

5. Enclosure Lifting Rings: Remove rings following installation and plug holes.

F. Field Finishing: Refer to Section 09_96_01 – High Performance Coating.

## 3.03 FIELD QUALITY CONTROL

A. General:
   1. Coordinate PIC testing with Owner and affected Subcontractors.
   2. Notify Engineer of Performance Test schedule 4 weeks prior to start of test.
   3. Engineer may actively participate in tests.
   4. Engineer reserves right to test or retest specified functions.
   5. Engineer's decision will be final regarding acceptability and completeness of testing.

B. Onsite Supervision:
   1. Require PIC site representative to supervise and coordinate onsite PIC activities.
   2. Require PIC site representative to be onsite while onsite work covered by this section and PIC subsystems is in progress.

C. Leak Tests: During preparation for testing, conduct leak tests in accordance with Section 40_41_00, Process Piping and Equipment.

D. Testing Sequence:
   1. Provide Functional Tests and Performance Tests for facilities as required to support staged construction and startup of plant.
   2. Refer to article Sequence of Work under Section 01_32_21, Schedules and Reports, for a definition of project milestones.
   3. Refer to Section 01_75_17 – Commissioning, for overall testing requirements.
   4. Completion: When tests (except Functional Test) have been completed and required test documentation has been accepted.

E. Testing:
   1. Prior to Facility Startup and Performance Evaluation period for each facility, inspect, test, and document that associated PIC equipment is ready for operation. Divide Functional Test for each facility into two parts.
   2. Functional Test:
      a. Scope: Confirm PIC, including applications software, is ready for operation.
      b. Functional Test Part 1: Performed by PIC System Integrator to test and document PIC, excluding Process Control Consultant provided applications software, is ready for operation. For PIC Subsystems for which Process Control Consultant provides applications software, provide sufficient temporary software configuring to allow testing of these subsystems.
         1) Loop/Component Inspections and Tests:
            a) These inspections and tests will be spot checked by Engineer.
            b) Check PIC for proper installation, calibration, and adjustment on loop-by-loop and component-by-component basis.
            c) Provide space on forms for signoff by PIC System Integrator.

d) Use loop status report to organize and track inspection, adjustment, and calibration of each loop and include the following:
   (1) Project name.
   (2) Loop number.
   (3) Tag number for each component.
   (4) Checkoffs/Signoffs for Each Component:
      (a) Tag/identification.
      (b) Installation.
      (c) Termination wiring.
      (d) Termination tubing.
      (e) Calibration/adjustment.
   (5) Checkoffs/Signoffs for the Loop:
      (a) Panel interface terminations.
      (b) I/O interface terminations with PLCs.
   (6) I/O Signals for PLCs, are Operational: Received/sent, processed, adjusted.
   (7) Total loop operational.
   (8) Space for comments.

2) Component calibration sheet for each active I&C component (except simple hand switches, lights, gauges, and similar items) and each PLCs, I/O module and include the following:
   a) Project name.
   b) Loop number.
   c) Component tag number or I/O module number.
   d) Component code number for I&C elements.
   e) Manufacturer for I&C elements.
   f) Model number/serial number for I&C elements.
   g) Summary of Functional Requirements; For Example:
      (1) Indicators and recorders, scale and chart ranges.
      (2) Transmitters/converters, input and output ranges.
      (3) Computing elements' function.
      (4) Controllers, action (direct/reverse) and control modes (P, I, D).
      (5) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
      (6) I/O Modules: Input or output.
   h) Calibrations, for example, but not limited to:
      (1) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
      (2) Discrete Devices: Actual trip points and reset points.
      (3) Controllers: Mode settings (P&ID).
      (4) I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.
      (5) Space for comments.
3) Maintain loop status reports, valve adjustment sheets, and component calibration sheets at Site, and make them available to Engineer at all times.
4) Engineer reviews loop status sheets and component calibration sheets and spot-check their entries periodically, and upon completion of Preparation for Testing. Correct deficiencies found.

5) Forms: See Loop Status Report, Instrument Calibration Sheet, and I&C Valve Adjustment Sheet referenced in Article Supplements.
6) Required Test Documentation: Test procedures, forms, and checklists. Signed by Engineer and Contractor except for Functional Test 1 items signed only by Contractor.
7) All testing and wiring issues to be corrected prior to scheduling Functional Test Part 2.

c. Functional Test Part 2: Combined effort between Contractor, PIC System Integrator, and Process Control Consultant to confirm PIC, including applications software, is ready for operation.
1) Witnessed by Owner or owner's representative.
2) Conducted with PICs and Owner's programming team.
3) Prerequisite: Completion of Functional Test Part 1.
4) Joint test with Process Control Consultant. Repeat of Process Control Consultant's SSDT application software tests, except using real field sensors and equipment. Plant interlocking and communications with PLCs and HMI tested on loop-by-loop basis.
5) Test procedures provided by Process Control Consultant.
6) Test results shall be documented on the IO list.
7) Completed when Functional Test has been conducted and Process Control Consultant has spot-checked associated test forms and checklists in field.
8) All testing and wiring issues to be corrected prior to scheduling Performance Test.
a) Discretes - to be tested by having final element change state.
(1) Pressure switches to be activated via handheld pressure pump.
b) If process or device prevents safe testing, jumper at device terminals or furthest location from PLC where the wiring can be safely tested.
c) Analogs - to be tested using actual instrument:
(1) Using actual sensing element in the process stream.
(a) Pressure transmitters to be tested via handheld pressure pump.
(2) Analytics to be tested with calibration solutions.
(3) Using simulate feature of instrument transmitter.
d) Tested using signal generator at 4, 12, 20 mA.
9) Digital or analog outputs that control equipment to be tested only after certificate of proper installation provided for the device and the device has been operated via local hand switches and controls.

3. Performance Test During and After Facility Startup:
a. Once a facility's Functional Test has been completed and that facility has been started up, perform a witnessed Performance Test on associated PIC equipment to demonstrate that it is operating as required by Contract Documents. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis operating in all modes of operation (Local, Remote Manual, and Remote Auto modes).
1) Witnessed by Owner or owner's representative.
2) Conducted with PIC System Integrator, Process Control Consultant, Owner and Owner's programming team.
3) Documented on the Performance Test testing forms.

b. Loop-specific and non-loop-specific tests same as required for FDT except that entire installed PIC tested using actual process variables and functions demonstrated.
c. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
d. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
e. Make updated versions of documentation required for Performance Test available to Engineer at Site, both before and during tests.
f. Make O&M data available to Engineer at Site both before and during testing.
g. Follow daily schedule required for FDT.
h. Determination of Ready for Operation: When Functional Test has been completed.
i. Refer to examples of Performance Test procedures and forms in Article Supplements.

## 3.04 TRAINING

A. The cost of training programs to be conducted with Owner's personnel shall be included in the Contract price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

B. The supplier shall provide detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the Project.

C. The supplier shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to Owner.

D. The training program shall represent a comprehensive program covering all aspects of the operation, maintenance and cleaning procedures for the system.

E. All training schedules shall be coordinated with, and at the convenience of the Owner. Shift training may be required to correspond to the Owner's working schedule.

F. The Contractor shall provide training and instruction to thoroughly familiarize the Owner's operations and maintenance personnel with the use, maintenance, calibration, repair and replacement of all components of the DAC System. The training shall be scheduled concurrent with the calibration, equipment testing, process system testing, and start-up testing phases of the project.

G. Training shall be performed by qualified representatives of the PICS System Supplier. Training shall be specifically tailored to this Project and reflect the PICS system installation and configuration. All training shall be conducted at the jobsite, unless an alternate location is approved by the Engineer and the Owner. The following table summarizes the training hours required, which shall be provided at no additional cost to the Owner:

| Training Class | Maintenance Class | Operator Class | Conducted By |
|---|---|---|---|
| PICS Hardware<br>General Familiarity | 2 | 2 | PICS Supplier (Process Instrumentation Control Supplier) |
| Field Terminal Hardware<br>(General familiarity, capabilities, limitations and configuration) | 2 | 2 | PICS Supplier |

H. Each training class shall be not more than 7 hours in duration. Separate classes shall be conducted for the Owner's operation and maintenance personnel. Operator classes shall emphasize operational theory and use of the PICS system. Maintenance classes shall stress troubleshooting, repair, calibration, replacement, and other technical aspects of the DAC system.

I. Each of the training classes listed above for Operators shall be conducted twice during separate weeks to allow for scheduling of the Owner's personnel. A total of 4 hours of training for maintenance personnel and 4 hours of training for operations personnel shall be provided.

J. Training classes shall be scheduled a minimum of 3 weeks in advance. Proposed training material, including a resume for each proposed instructor and a detailed class outline/lesson plan shall be submitted to the Engineer at least 60 days in advance of when the training is scheduled to begin. The Engineer and the Owner shall review the submitted data for suitability and provide comments and requested changes that shall be incorporated into the training plan.

K. Within 10 days of completion of each training class, the Contractor shall present to the Engineer the following:
   1. A list of all Owner personnel attending the class.
   2. A copy of the text utilized during the class with all notes, diagrams, and comments.

## 3.05 WARRANTY/PREVENTIVE MAINTENANCE

A. A written maintenance contract executed by the supplier shall be provided to the Owner for onsite warranty and preventive maintenance services. This maintenance contract shall include all labor, parts, and emergency calls providing onsite response within 24 hours, to provide complete system maintenance for a period of one year after the date of final acceptance of the system.

B. The maintenance contract shall also include a minimum of 12 (monthly) preventive maintenance visits by a qualified serviceman of the supplier who is familiar with the type of equipment and software provided for this Project. Each preventive maintenance visit shall include routine adjustment, calibration, cleaning and lubrication of system equipment and verification of correct software operation.

C. Emergency maintenance procedures or plant visits may coincide with a preventive maintenance visit, however, they shall not replace the work intended to be performed during a preventive maintenance visit. The supplier shall have full responsibility for the system hardware and software preventive and corrective maintenance.

D. During the 1-year maintenance period, observation of maintenance operations by Owner's personnel and the instruction of said personnel in the details of the maintenance work being performed, shall be provided. At the end of the maintenance contract period, the Supplier shall replenish the spare parts supply to the original status of component parts and physical condition.

E. The costs for the 1-year warranty and preventive maintenance service contract shall be included in the Contract Price, but as a separate line item which may be deleted by the Owner for a full credit anytime before final acceptance of the system.

F. An annual fee shall be quoted within 90 days after final acceptance for the purpose of entering a contract for annual maintenance subsequent to the first year of maintenance. Standard per diem rates for providing breakdown service shall be set forth in the Contract. Such rates shall be fair and reasonable and reflect the lowest rates offered to most favored customers. The fee quoted shall be firm for a minimum of 90 days from date of issue.

G. During the 1-year maintenance period, the original programmer of the PLC logic or person who has intimate knowledge of the software and approved by County shall respond within 24 hours by phone and 48 hours onsite to request for corrective actions. If programmer fails to respond within given time, the County will back charge the Contractor for taken actions.

## 3.06 CONTROL SYSTEM DIAGRAMS AND DETAILS

A. To assist the system supplier in determining the requirements included, a series of loop diagrams and details are provided. Unless specifically stated otherwise, the system supplier shall be responsible for providing all instrumentation, control equipment and auxiliary devices necessary to perform the functions specified herein and as shown and described on these diagrams. Any auxiliary devices such as lightning/surge protectors, relays, timers, signal isolators, signal boosters, etc., which are necessary for complete operation of the system, or to perform the functions specified shall be included, whether or not they are specifically shown or tabulated on the loop diagrams.

B. The intent of the loop diagrams is to describe in as much detail as possible, the hardware, software and functional requirements of a process measurement or control system. They are not intended to convey requirements for conduit and wiring between panels or system components. This information is included in appropriate electrical.

## 3.07 CLEANING

A. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

## 3.08 PROTECTION

A. Use corrosion-inhibiting vapor capsules in enclosures to protect electrical, instrumentation, and control devices, including spare parts, from corrosion.

B. Periodically replace capsules based on capsule manufacturer’s recommendations.

## 3.09 SUPPLEMENTS

A. Supplements listed below, follows “End of Section,” are part of this Specification.
   1. Instrument List.

END OF SECTION

**ATTACHMENT A**

INSTRUMENT LIST

| TAG NUMBER | DEVICE | SPECIFICATION CODE | RANGE | Line Size | DWG No. | COMMENT |
|---|---|---|---|---|---|---|
| FIT-624 | MAGNETIC FLOW METER | F4 | 0-xxx gpm | 36 inch | 00N01 | DRUM SCREENS INFLUENT FLOW |
| FIT-611 | MAGNETIC FLOW METER | F4 | 0-xxx gpm | 18 inch | 00N01 | CHLORINE CONTACT BASIN PIT LEVEL |
| FIT-613 | MAGNETIC FLOW METER | F4 | 0-xxx gpm | 24 inch | 00N01 | CHLORINE CONTACT BASIN PIT LEVEL HIGH |
| 17-FIT-02 | MAGNETIC FLOW METER | F4 | 0-xxx gpm | 24 inch | 00N01 | CHLORINE CONTACT BASIN PIT LEVEL LOW |

# SECTION 40_91_00

# INSTRUMENTATION AND CONTROL COMPONENTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. This section gives general requirements for instrumentation and control components.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. Article Mechanical Systems Components covers requirements of mechanical PIC components that are not specifically referenced by Section 40_90_00 - Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.

B. Article Electrical Components covers requirements for electrical PIC components that are not specifically referenced by Section 40_90_00 - Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.

C. All other Part 2 articles cover components that are referenced by Instrument Lists or Data Sheets in Section 40_90_00 - Instrumentation and Control for Process Systems, or by specific component numbers in other PIC subsections.

D. All pressure instruments shall be provided with isolation valves and calibration ports.

E. All outside instruments shall be provided with Surge Protection Device on signal and power wires.

F. Instrument calibration shall be to actual process range and not instrument range.

### 2.02 MECHANICAL SYSTEMS COMPONENTS

A. Flow Element, Rotameter, Purge:
   1. For air or water service, unless otherwise noted.
   2. Materials: Glass tube, fiberglass body, stainless steel float, nylon ball check valve.
   3. Direct-Reading Scale Length: 2-1/2 inches, minimum.
   4. Scale Ranges: 0 scfh to 2.5 scfh for air service or 0 gph to 10 gph for water service.
   5. Integral inlet needle valves.
   6. Integral differential pressure regulators:
      a. For water service.
      b. For air service for level ranges greater than 10 feet of water.

7. Rotameters for water service.
8. Manufacturers and Products:
    a. Fischer & Porter; Series 10A3130.
    b. Brooks; Series DS-1350.

B. Manifold, Three-Valve Equalizing:
1. Type: For isolation and equalization of differential pressure transducers.
2. Materials: Stainless steel.
3. Manufacturers and Products:
    a. Anderson, Greenwood and Co.; Type M1.
    b. Evans.

C. Pressure Gauge: For other than process variable measurement.
1. Dial Size: Nominal 2-inch dial size.
2. Accuracy: 2 percent of span.
3. Scale Range: Such that normal operating pressure lies between 50 percent and 80 percent of scale range.
4. Connection: 1/4-inch NPT through bottom, unless otherwise noted.
5. Manufacturers and Products:
    a. Ashcroft; Duragauge Model 1259/Model, 1279/Model, 1279 PLUS!
    b. Ametek U.S. Gauge; Solfrunt Model 19XX/1981Advantatge.
    c. WIKA, Type 2XX.34.
    d. Approved equal.

D. Valve, Needle:
1. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
2. Size: 0.020-inch orifice.
3. Manufacturers and Products:
    a. Whitey; Model 21RF2.
    b. Hoke; 3700 Series.

E. ON/OFF Valves:
1. Type: Ball valve.
2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
    a. Whitey; Series 41 through Series 43.
    b. Hoke; Flomite 7100 Series.

F. Regulating Valves:
1. Type: Needle valves, with regulating stems and screwed bonnets.
2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
    a. Whitey; Catalog No. RF or No. RS.
    b. Hoke; 3100 through 3300 Series.

G. Valve, Three-Way:
   1. Type: Ball valve.
   2. Materials: Brass or stainless steel with nylon handle as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
   3. Manufacturers and Products:
      a. Whitey; Series 41 through Series 43.
      b. Hoke; Selecto-Mite Series.

H. Valve, Four-Way:
   1. Type: Four-way, two-position ball valve.
   2. Materials:
      a. Body and Stem: Type 316 stainless steel.
      b. Handle: Black nylon.
      c. Packing Gland: Teflon.
   3. Ball and stem bed, one-piece assembly.
   4. Machined handle stops and directional nameplates.
   5. Manufacturers and Products:
      a. Whitey; Series 457.
      b. Hoke; Multi-Mite Series.

I. Spool Valve:
   1. Type: Five-port arrangement as shown, two-position, push-to-operate knob attached to the spool stem, and spring return.
   2. Materials: Aluminum construction with Teflon impregnated aluminum spool, stainless steel spring, and Buna-N O-rings.
   3. Port Connection: 1/4-inch outside diameter tube fittings.
   4. Manufacturer and Product: Norgren; T71DAOO-TSO-TKO.

J. Solenoid Valve, Two-Way:
   1. Type: Globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation.
   2. Materials:
      a. Body: Brassed or stainless steel globe valves as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
      b. Valve Seat: Buna-N.
   3. Size: Normally closed or opened, as noted.
   4. Coil: 115V ac, unless noted otherwise.
   5. Solenoid Enclosure: NEMA 4.
   6. Manufacturer and Product: ASCO; Red Hat Series 8260.

K. Pressure Regulator, Water:
   1. Materials:
      a. Body: Bronze.
      b. Spring Case: Cast iron.
      c. Seat Rings: Brass.
      d. Valve Disk and Holder: Buna-N and bronze.
      e. Diaphragm: Buna-N diaphragm.
   2. Sizing: For maximum of 7 psi offset pressure.
   3. Manufacturers and Products:
      a. Fisher; Controls Type 95H or 95L.
      b. Masoneilan; Series 17.

L. Test Tap:
   1. Manufacturers and Products:
      a. Imperial-Eastman; quick-disconnect couplings No. 292-P and caps No. 259-P.
      b. Crawford Fitting Co.; Swagelok quick-connects Series QC4 and caps QC4-DC.
      c. Parker; CPI Series precision quick couplings.

M. Copper Tubing and Fittings:
   1. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
   2. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on Drawings.
   3. Manufacturers:
      a. Parker-Hannifin.
      b. Swagelok tube fittings.

N. Plastic Tubing and Fittings:
   1. Tubing:
      a. Polyethylene capable of withstanding 190 psig at 175 degrees Fahrenheit.
      b. Manufacturers and Products:
         1) Dekoron; Type P.
         2) Imperial Eastman; Poly-Flo black instrument tubing.
   2. Fittings:
      a. Type: Brass compression.
      b. Manufacturers and Products:
         1) Imperial Eastman; Poly-Flo tube fittings.
         2) Dekoron; E-Z fittings.

O. Stainless Steel Tubing: ASTM A312/A312M, Type 316, 0.065-inch wall, seamless, soft annealed, as shown on Drawings.

P. Stainless Steel Fittings:
   1. Compression Type:
      a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, flareless.
      b. Manufacturers and Products:
         1) Parker Flodar; BA Series.
         2) Swagelok tube fittings.
         3) Parker CPI tube fittings; Parker A-LOK dual ferrule tube fittings.
   2. Socket Weld Type:
      a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, 3,000 psi maximum working pressure, safety factor 4:1.
      b. Manufacturers:
         1) Cajon.
         2) Swagelok.
         3) Parker WELDLOK.

Q. Purge Set:
   1. Parts: Purge rotameter flow element, pressure regulator, pressure gauge, test tap, shutoff valve, spool valve, and interconnecting tubing as shown on Drawings and as required in this section.
   2. Pressure Gauge Scale Range: 150 percent of the process variable.
   3. Mounting:
      a. Within consoles, panels, or a separate enclosure as shown.
      b. For separate enclosure mounted purge sets, refer to paragraphs Nonfreestanding Panel Construction and Factory Finishing for enclosure requirements.

R. Tubing Raceways:
   1. Cable tray systems complete with tees, elbows, reducers, and covers.
   2. Size in accordance with manufacturer's recommendations for intended service.
   3. Materials: Galvanized steel or aluminum brass as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
   4. Manufacturers:
      a. Globetray.
      b. Cope.

## 2.03 ELECTRICAL COMPONENTS

A. Terminal Blocks for Enclosures:
   1. General:
      a. Connection Type: Screw compression clamp.
      b. Compression Clamp:
         1) Complies with DIN-VDE 0611.
         2) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
         3) Guides strands of wire into terminal.
      c. Screws: Hardened steel, captive, and self-locking.
      d. Current Bar: Copper or treated brass.
      e. Insulation:
         1) Thermoplastic rated for minus 55 degrees Celsius to plus 110 degrees Celsius.
         2) Two funneled shaped inputs to facilitate wire entry.
      f. Mounting:
         1) Standard DIN rail.
         2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
         3) End Stops: Minimum of one at each end of rail.
      g. Wire Preparation: Stripping only permitted.
      h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
      i. Marking System:
         1) Terminal number shown on both sides of terminal block.
         2) Allow use of preprinted and field marked tags.
         3) Terminal strip numbers shown on end stops.

4) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

j. Test Plugs: Soldered connections for 18 AWG wire.
1) Pin Diameter: 0.079 inch.
2) Quantity: 10.

2. Terminal Block, General Purpose:
a. Rated Voltage: 600V ac.
b. Rated Current: 30 amps.
c. Wire Size: 24 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body.
f. Spacing: 0.25 inch, maximum.
g. Test Sockets: One screw test socket 0.079-inch diameter.

3. Terminal Block, Ground:
a. Wire Size: 24 AWG to 10 AWG.
b. Rated Wire Size: 10 AWG.
c. Color: Green and yellow body.
d. Spacing: 0.25 inch, maximum.
e. Grounding: Electrically grounded to mounting rail.

4. Terminal Block, Blade Disconnect Switch:
a. Rated Voltage: 600V ac.
b. Rated Current: 10 amp.
c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body, orange switch.
f. Spacing: 0.25 inch, maximum.

5. Terminal Block Diode:
a. Rated Voltage: 24V dc.
b. Rated Current: 30 ma.
c. Wire Size: 16 AWG.

6. Terminal Block, Fused, 24V dc:
a. Rated Voltage: 600V dc.
b. Rated Current: 25 amp.
c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body.
f. Fuse: 0.25 inch by 1.25 inches.
g. Indication: LED diode 24V dc.
h. Spacing: 0.512 inch, maximum.

7. Terminal Block, Fused, 120V ac:
a. Rated Voltage: 600V ac.
b. Rated Current: 25 amp.
c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body.
f. Fuse: 0.25 inch by 1.25 inches.
g. Indication: Neon lamp, 110V ac.
h. Leakage Current: 1.8 mA, maximum.
i. Spacing: 0.512 inch, maximum.

8. Terminal Block, Fused, 120V ac, High Current:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 35 amps.
    c. Wire Size: 18 AWG to 8 AWG.
    d. Rated Wire Size: 8 AWG.
    e. Color: Gray.
    f. Fuse: 13/32 inch by 1.5 inches.
    g. Spacing: 0.95 inch, maximum.
9. Manufacturers:
    a. Phoenix-Contact.
    b. Weidmuller.
    c. Allen Bradley.

B. Relays:
1. General:
    a. Relay Mounting: Plug-in type socket.
    b. Relay Enclosure: Furnish dust cover.
    c. Socket Type: Screw terminal interface with wiring.
    d. Socket Mounting: Rail.
    e. Provide holddown clips.
2. Signal Switching Relay:
    a. Type: Dry circuit.
    b. Contact Arrangement: 2 Form C contacts.
    c. Contact Rating: 5 amps at 28V dc or 120V ac.
    d. Contact Material: Gold or silver.
    e. Coil Voltage: As noted or shown.
    f. Coil Power: 0.9 watt (dc), 1.2VA (ac).
    g. Expected Mechanical Life: 10,000,000 operations.
    h. Expected Electrical Life at Rated Load: 100,000 operations.
    i. Indication Type: Neon or LED indicator lamp.
    j. Seal Type: Hermetically sealed case.
    k. Manufacturer and Product: Potter and Brumfield; Series KH/KHA.
3. Control Circuit Switching Relay, Nonlatching:
    a. Type: Compact general purpose plug-in.
    b. Contact Arrangement: 3 Form C contacts.
    c. Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
    d. Contact Material: Silver cadmium oxide alloy.
    e. Coil Voltage: As noted or shown.
    f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
    g. Expected Mechanical Life: 10,000,000 operations.
    h. Expected Electrical Life at Rated Load: 100,000 operations.
    i. Indication Type: Neon or LED indicator lamp.
    j. Push-to-test button.
    k. Manufacturer and Product: Potter and Brumfield; Series KUP.
4. Control Circuit Switching Relay, Latching:
    a. Type: Dual coil mechanical latching relay.
    b. Contact Arrangement: 2 Form C contacts.
    c. Contact Rating: 10A at 28V dc or 120V ac.
    d. Contact Material: Silver cadmium oxide alloy.
    e. Coil Voltage: As noted or shown.
    f. Coil Power: 2.7 watts (dc), 5.3VA (ac).

g. Expected Mechanical Life: 500,000 operations.
h. Expected Electrical Life at Rated Load: 50,000 operations.
i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.

5. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 30V dc or 277V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Operating Temperature: Minus 10 degrees Celsius to 55 degrees Celsius.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay set point fall between 20 percent to 80 percent of range.
   i. Time Delay Set Point: As noted or shown.
   j. Mode of Operation: As noted or shown.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
   l. Manufacturer and Products: Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1-second to 120-second delay time ranges.

C. Surge Suppressors:
1. General:
   a. Construction: First-stage high-energy metal oxide varistor and second-stage bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
   b. Response: 5 nanoseconds maximum.
   c. Recovery: Automatic.
   d. Temperature Range: Minus 20 degrees Celsius to plus 85 degrees Celsius.
2. Suppressors on 120V ac Power Supply Connections:
   a. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
   b. First-Stage Clamping Voltage: 350 volts or less.
   c. Second-Stage Clamping Voltage: 210 volts or less.
   d. Continuous Operation: Power supplies for one four-wire transmitter or receiver: 5 amps minimum at 130V ac. All other applications: 30 amps minimum at 130V ac.
3. Suppressors on Analog Signal Lines:
   a. Test Waveform: Linear 8 microsecond rise in current form 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
   b. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
      1) dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
      2) dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
      3) Maximum Loop Resistance: 18 ohms per conductor.
4. Physical Characteristics:
   a. Mounted in Enclosures: Encapsulated inflame retardant epoxy.
   b. For Analog Signals Lines: EDCO PC-642 or SRA-64 series.
   c. For 120V ac Lines: EDCO HSP-121.

d. Field Mounted at Two-Wire Instruments: Encapsulated in stainless steel pipe nipples. EDCO SS64 series.
e. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
    1) Enclosure:
        a) NEMA 4X fiberglass or Type 316 stainless steel with door.
        b) Maximum Size: 12 inches by 12 inches by 8 inches deep.
    2) Manufacturer and Product: EDCO; SLAC series.

D. Power Supplies:
1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
2. 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.
3. Provide output over voltage and over current protective devices to:
    a. Protect instruments from damage due to power supply failure.
    b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
    a. Type: Indicating.
    b. Mount so fuses can be easily seen and replaced.

E. Power Supplies with DC UPS system:
1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
2. 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.
3. Provide output over voltage and over current protective devices to:
    a. Protect instruments from damage due to power supply failure.
    b. Protect power supply from damage due to external failure.
4. Power supply shall have built in DC UPS system that will have battery backup and automatically switch to battery supply upon AC power loss. It shall have continuous battery efficiency monitoring and battery charging capability.
5. Enclosures: NEMA 1.
6. Mount such that dissipated heat does not adversely affect other components.
7. Fuses: For each dc supply line to each individual two-wire transmitter.
    a. Type: Indicating.
    b. Mount so fuses can be easily seen and replaced.

F. Intrinsic Safety Barriers:
1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
    a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.
2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
    a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.

G. Analog Signal Isolators:
   1. Isolation: Input, output and power.
   2. Input impedance: 50 ohms.
   3. Output: Up to 1200 ohms.
   4. Span: Adjustable.
   5. Zero: Adjustable.
   6. RFI/EMI Immunity: 10 V/mat 20 to 500 MHz.
   7. Mounting: DIN rail.
   8. Power: 120 VAC.
   9. Moore Industries Model ECT or equal.

## 2.04 ANALYTICAL COMPONENTS

A. A7 pH Element and Transmitter:
   1. General.
      a. Function: Measure, indicate, and transmit pH of process fluid.
      b. Parts: Element, analyzer/transmitter, interconnecting cable, and noted ancillaries.
   2. Performance:
      a. Element:
         1) Range: 0 pH to 14 pH.
         2) Operating Temperature: 32 degrees Fahrenheit to 158 degrees Fahrenheit.
         3) Operating Pressure: 80 psig maximum at 149 degrees Fahrenheit.
      b. Analyzer/Transmitter:
         1) Range: 0 pH to 14 pH units.
         2) Accuracy: Plus or minus 0.02 pH units.
         3) Repeatability: Plus or minus 0.05 pH units.
         4) Stability: Plus or minus 0.01 pH units per month, noncumulative.
         5) Operating Temperature: Minus 4 degrees Fahrenheit to plus 104 degrees Fahrenheit.
         6) Operating Humidity: 5 percent to 95 percent; relative humidity, noncondensing.
   3. Element:
      a. Process Connection: 1-inch MNPT.
      b. Body Style: Convertible with 1-inch NPT on both ends.
      c. Process Fluid: As noted.
      d. Wetted Materials: Compatible with process fluid.
      e. No field-replaceable parts, unless otherwise noted.
      f. Electrode Type: Flat glass or general purpose, unless otherwise noted.
      g. Integral Preamplifier: Required, unless otherwise noted.
      h. Mounting/Process Connections: As shown on Drawings or as noted from among the following:
         1) Flow-through: 1-1/2-inch NPT tee.
   4. Analyzer/Transmitter:
      a. Display: Graphic LCD, with back-lighting.
      b. Signal Interface:
         1) Analog Outputs: Two isolated 4 mA to 20 mA dc outputs (pH and temperature).
         2) Discrete Outputs:
            a) Process Alarms: Two SPSTs minimum, normally open.

b) Sensor/Analyzer and Process Fault Alarm: SPDT.
c) Contact Rating: 120V, 5 amps, resistive.

c. Enclosure.
1) Type: NEMA 4X.
2) Suitable for panel, 2-inch pipe, or wall mounting.

d. Power: 115V ac, 50/60-Hz, unless otherwise noted.

e. Interconnecting Cable: Length as required.

5. Expendables (for each unit provided):
a. Chemicals: 1 pint each of buffer solution for pH 4, pH 7, and pH 9.

6. Accessories:
a. Junction Box: If noted.
1) NEMA 4X box for cable extension.

7. Manufacturers and Products:
a. Rosemount Analytical; Model 399 (water), Model 396P (wastewater), or Model 390R (retractable) sensor and Model 54e pH analyzer.

B. A9 pH/ORP Sensor and Analyzer:
1. pH/ORP Analyzer:
a. The analyzer shall be microprocessor-based and accept a GLI 5-wire Differential Technique sensor, a conventional combination electrode, or an electrode pair. It shall also accept an external temperature sensor (Pt 1000 or NTC 300 ohm thermistor for Differential sensor, or Pt 100 or Pt 1000 for conventional combination electrode).
b. The analyzer shall have predictive diagnostics to forecast the end of sensor life, and reactive diagnostics for alerting the operator to changes in vital electrode data including measuring and reference electrode impedance, zero, and slope.
c. The analyzer shall have an automatic logbook for recording up to 100 system events including calibrations, electrode performance statistics, warning and failure messages, power-up/power-down, relay overfeed timer "time outs," and configuration activity. Each event is logged with its date and time of occurrence.
d. The analyzer shall have a graphical dot matrix LCD display with 128 x 64 pixels and LED backlighting. The main display character height shall be 1/2 inch (13 mm). Auxiliary information character height shall be 1/8 inch (3 mm). Menu screens shall contain up to six full lines of conversational text.
e. The analyzer main display shall indicate pH. Simultaneously displayed auxiliary information shall include analog output values, process temperature, the date and time, the pH sensor's mV output, electrode impedance, relay status, diagnostic warnings, or error messages.
f. The pH analyzer shall have four pH calibration methods:
1) Arbitrary: Enter known value of buffer for each point.
2) Pre-defined (1 or 2-point): Automatic calibration and buffer recognition using buffers from one of the five built-in buffer sets.
3) Sample (1 or 2-point): Enter known value of sample determined by laboratory analysis or comparison reading.
g. The analyzer shall have a user-assigned passcode to restrict access to configuration settings for authorized personnel only.

h. The analyzer shall have fail high, warn high, warn low, and fail low software alarm settings for the measured pH, temperature, electrode zero point, electrode slope, active (or glass) electrode impedance, and standard (or reference) electrode impedance. Also, fail high and warn high software alarm settings are provided for the calibration timer.
i. The analyzer shall have diagnostic screens for messages (including scrolling lists for fail and warn alarm conditions), calibration records, sensor statistics for the first and last three calibrations, logbook, analyzer hardware tests, device description, and factory assistance.
j. The analyzer shall automatically retain calibration records, including the date and time of the last calibration, type of calibration performed, and important electrode statistics such as zero, slope, and electrode impedance.
k. The analyzer shall have self-check functions for all memory chips, the keypad, and display pixels.
l. The analyzer shall have two sets of isolated analog outputs. Each set shall consist of 0-1 mA/ 0-5 VDC and 4-20 mA. Each output set can be assigned to represent the measured pH, or temperature. Output 2 can provide the normal proportional output, or a special dedicated non-proportional alarm signal (selectable for 4 mA or 20 mA only). pH or temperature values can be entered to define the endpoints at which the minimum and maximum output values are desired.
m. The analyzer shall have an optional PID controller with a software selectable ISA or velocity algorithm. Also, the controller shall have an output timer alarm.
n. The analyzer shall have a user-set calibration timer to alert the operator to perform scheduled calibration.
o. The analyzer shall be powered by 120VAC, and shall be:
    1) Hach Model GLI P63.

2. pH/ORP Sensor:
    a. The pH sensor shall be of Differential Electrode Technique design using two electrodes to compare the process value to a stable internal reference standard buffer solution. The standard electrode shall have non-flowing and fouling-resistant characteristics.
    b. The sensor shall have a hex-shaped body to facilitate mounting, and shall be constructed of PEEK® material for exceptional chemical resistance and mechanical strength. This material shall enable the sensor to be installed in metal fittings without leakage usually caused by heating and cooling cycles when dissimilar materials are threaded together.
    c. The sensor shall have a: a) Convertible body style featuring 1-inch NPT threads on both ends to mount into a standard 1-inch pipe tee, into a GLI adapter pipe for union mounting with a standard 1-1/2 inch tee, or onto the end of a pipe for immersion into a vessel. b) Insertion body style featuring 1-inch NPT threads only on the cable end to mount into a GLI ball valve hardware assembly, enabling the sensor to be inserted into or retracted from the process without stopping the process flow. c) Sanitary body style featuring an integral 2-inch flange to mount into a GLI 2-inch sanitary tee. The sanitary body style sensor shall include a special cap and EDPM compound gasket for use with the GLI sanitary hardware.
    d. The built-in electronics of the sensor shall be completely encapsulated for protection from moisture and humidity.

e. The sensor shall have a built-in preamplifier to enable the signal to be transmitted up to 3000 ft. (914 m) with standard cabling.
f. The sensor signal shall have an integral temperature sensor to automatically compensate measured values for changes in process temperature.
g. The sensor shall include a titanium ground electrode (standard) to eliminate ground loop currents in the measuring electrodes:
    1) The sensor shall be GLI International, Inc. Model PDXP-series for pH measurement.
h. Manufacturers:
    1) Analyzers: One of the following, no equals:
        a) Hach GLI.
        b) Yokogawa.
        c) Rosemount.
    2) Sensors:
        a) Hach GLI.
        b) Yokogawa.
        c) Rosemount.

C. A27 Total Chlorine Residual Analyzer, No Reagents:
1. General:
    a. Function:
        1) Measure and indicate total chlorine and pH of sample.
        2) Transmit proportional analog signal.
    b. Type:
        1) Principle: Amperiometric or polarographic membrane sensor.
        2) Reagents not required.
    c. Parts: Sensor, analyzer/transmitter, and accessories.
2. Performance:
    a. Species Measured: Total chlorine.
    b. Service: Potable water treatment unit processes, unless otherwise noted.
    c. Process Range: As noted.
    d. Analyzer Range: Single 0 mg/L to 20.0 mg/L range or multiple ranges within 0 mg/L to 20.0 mg/L.
    e. Linearity:
        1) 0.1 percent of full scale, or from 0 mg/L to 20 mg/L, one percent as per IEC 60746.
    f. Response Time to Step Change: Less than 120 seconds to 90 percent of final value.
    g. Sample Conductivity: Greater than 10 microS/cm.
    h. Sample Temperature Range: 32 degrees Fahrenheit to 104 degrees Fahrenheit.
    i. Operating Ambient Temperature Range:
        1) 32 degrees Fahrenheit to 122 degrees Fahrenheit.
        2) Minus 4 degrees Fahrenheit to 140 degrees Fahrenheit, but with possible degradation in display performance.
3. Features:
    a. Sensor:
        1) Electrodes and either amperiometric or polarographic membrane sensor.
        2) pH Sensor: Required.

3) Flow Cell:
a) Constant head.
b) 7 gph to 30 gph, minimum.
4) Inlet Pressure: 3 psig to 65 psig.
b. Analyzer: Two line display.
4. Enclosure:
a. NEMA 4X (IP-66), polycarbonate.
b. Suitable for wall mounting; furnish required accessories.
5. Signal Interface:
a. Analog Output:
1) Two 4 mA to 20 mA dc isolated outputs suitable for a load impedance up to 500 ohms.
2) Multiple range outputs or completely scaleable.
3) Assignable; chlorine and pH.
b. Discrete Outputs:
1) Two minimum SPDT, minimum 5 amps at 120V ac and 24V dc, resistive.
2) Selectable process alarms or fault.
6. Process Connections:
a. Sample Inlet: 1/4 inch.
b. Drain Connection: 1/2 inch or 3/4 inch.
7. Power: 120V ac, 60-Hz.
8. Accessories: Interconnecting cable.
9. Manufacturers and Products:
a. Hach CL 10sc Total Chlorine Analyzer with SC200 transmitter.
b. Or approved equal

D. A28 Free Chlorine Residual Analyzer, No Reagents:
1. General:
a. Function:
1) Measure and indicate total chlorine and pH of sample.
2) Transmit proportional analog signal.
b. Type:
1) Principle: Amperiometric or polarographic membrane sensor.
2) Reagents not required.
c. Parts: Sensor, analyzer/transmitter, and accessories.
2. Performance:
a. Species Measured: Total chlorine.
b. Service: Potable water treatment unit processes, unless otherwise noted.
c. Process Range: As noted.
d. Analyzer Range: Single 0 mg/L to 20.0 mg/L range or multiple ranges within 0 mg/L to 20.0 mg/L.
e. Linearity:
1) 0.1 percent of full scale, or from 0 mg/L to 20 mg/L, one percent as per IEC 60746.
f. Response Time to Step Change: Less than 120 seconds to 90 percent of final value.
g. Sample Conductivity: Greater than 10 microS/cm.
h. Sample Temperature Range: 32 degrees Fahrenheit to 104 degrees Fahrenheit.

i. Operating Ambient Temperature Range:
1) 32 degrees Fahrenheit to 122 degrees Fahrenheit.
2) Minus 4 degrees Fahrenheit to 140 degrees Fahrenheit, but with possible degradation in display performance.

3. Features:
a. Sensor:
1) Electrodes and either amperiometric or polarographic membrane sensor.
2) pH Sensor: Required.
3) Flow Cell:
a) Constant head.
b) 7 gph to 30 gph, minimum.
4) Inlet Pressure: 3 psig to 65 psig.
b. Analyzer: Two line display.
4. Enclosure:
a. NEMA 4X (IP-66), polycarbonate.
b. Suitable for wall mounting; furnish required accessories.
5. Signal Interface:
a. Analog Output:
1) Two 4 mA to 20 mA dc isolated outputs suitable for a load impedance up to 500 ohms.
2) Multiple range outputs or completely scaleable.
3) Assignable; chlorine and pH.
b. Discrete Outputs:
1) Two minimum SPDT, minimum 5 amps at 120V ac and 24V dc, resistive.
2) Selectable process alarms or fault.
6. Process Connections:
a. Sample Inlet: 1/4 inch.
b. Drain Connection: 1/2 inch or 3/4 inch.
7. Power: 120V ac, 60-Hz.
8. Accessories: Interconnecting cable.
9. Manufacturers and Products:
a. Hach CL 10sc Free Chlorine Analyzer, with SC200 transmitter.
b. Or approved equal.

E. Ammonia / Monochloramine Analyzer:
1. Type:
a. Ammonia and monochloramine microprocessor controlled analyzer for continuous monitoring of total and free ammonia and monochloramine in water.
b. Measures total ammonia and monochloramie and determine free ammonia concentration.
2. Function al/Operation:
a. Measurement range 0.01 to 2 ppm Ammonia or Monochloramine.
b. Detection limit 0.01 ppm Ammonia.
c. Accuracy - ±5 percent or 0.01 ppm for 5-40 degrees Celsius; ±10 percent or 0.02 ppm for 40-50 degrees Celsius.
d. Repeatability – 3 percent or 0.01 ppm whichever is greater.
e. Response time at T>90 percent - less than 5 minutes.
f. Power requirements – 115V , 60Hz supply.

g. Display – LCD with dashboard view with recent calibration information, reagent status, prognosys indicators.
h. Diagnostics - Shall have built-in self-test and auto-blanking between analysis points to compensate for sample color, turbidity and changes in light intensity.
i. Signal Output:
j. - 4 configurable Isolated 4-20 mA outputs.
k. - 4 electromechanical SPDT relays for user configurable contacts rated 115VAC.

3. Physical:
   a. Transmitter/Converter Enclosure - NEMA 4X.
   b. Mounting - Electronics case shall be suitable for pipe, unistrut, or wall mounting as required.
4. Manufacturers:
   a. Hach, Model APA 5500 Ammonia/Monochloramine Analyzer.

## 2.05 FLOW COMPONENTS

A. F4 Flow Element and Transmitter, Electromagnetic:
   1. General:
      a. Function: Measure, indicate, and transmit the flow of a conductive process liquid in a full pipe.
      b. Type:
         1) Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
         2) 0 x DN inlet/outlet runs, Full bore meter with magnetic field traversing entire flow-tube cross section.
         3) Unacceptable are insert magmeters or multiple single point probes inserted into a spool piece.
      c. Parts: Flow element, transmitter, interconnecting cables, and mounting hardware. Other parts as noted.
   2. Service:
      a. Stream Fluid:
         1) As noted.
         2) Suitable for liquids with a minimum conductivity of 5 microS/cm and for demineralized water with a minimum conductivity of 20 microS/cm.
      b. Flow Stream Descriptions: If and as described below.
   3. Operating Temperature:
      a. Element:
         1) Ambient: Minus 5 to 140 degrees Fahrenheit, typical, unless otherwise noted.
         2) Process: Minus 5 to 140 degrees Fahrenheit, typical, unless otherwise noted.
      b. Transmitter:
         1) Ambient: Minus 5 to 140 degrees Fahrenheit, typical, unless otherwise noted.
         2) Storage: 15 to 120 degrees Fahrenheit, typical, unless otherwise noted.

4. Performance:
    a. Flow Range: As noted.
    b. Accuracy: Plus or minus 0.5 percent of rate for all flows resulting from pipe velocities of 2 to 30 feet per second.
    c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
5. Features:
    a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
    b. No obstructions to flow.
    c. Very low pressure loss.
    d. Measures bi-directional flow.
6. Process Connection:
    a. Meter Size (diameter inches): As noted.
    b. Connection Type: 150-pound ANSI raised-face flanges; AWWA C207, Table 2 Class D; or wafer style depending on meter size, unless otherwise noted.
    c. Flange Material: Carbon steel, unless otherwise noted.
7. Power (Transmitter): 24VDC, unless otherwise noted.
8. Element:
    a. Meter Tube Material: Type 304 or 316 stainless steel, unless otherwise noted.
    b. Liner Material:
        1) Teflon, unless otherwise noted.
        2) For potable water service, must have appropriate approvals.
    c. Liner Protectors: Covers (or grounding rings) on each end to protect liner during shipment.
    d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
    e. Electrode Material: Type 316 stainless steel or Hastelloy C, unless otherwise noted.
    f. Grounding Ring:
        1) Required, unless otherwise noted.
        2) Quantity: Two, unless otherwise noted.
        3) Material: Type 316 stainless steel, unless otherwise noted.
    g. Enclosure: NEMA 4X, minimum, unless otherwise noted.
    h. Submergence:
        1) Temporary: If noted.
        2) Continuous (up to 10 feet depth), NEMA 6P/IP68: If noted.
    i. Direct Buried (3 to 10 feet): If noted.
    j. Hazardous Area Certification:
        1) Class 1, Division 2, Groups A, B, C, D: If noted.
        2) Class 1, Division 1, Groups A, B, C, D, and FM approved: If noted.
        3) Class 1, Division 1, Groups C, D, and FM approved: If noted.
9. Transmitter:
    a. Mounting: Surface (wall), unless otherwise noted.
    b. Display: Required, unless otherwise noted.
        1) Digital LCD display, indicating flow rate and total.
        2) Bi-directional Flow Display: Required, unless otherwise noted.
            a) Forward and reverse flow rate.
            b) Forward, reverse and net totalization.

c. Parameter Adjustments: By keypad or non-intrusive means.
d. Enclosure: NEMA 4X, minimum, unless otherwise noted.
e. Empty Pipe Detection:
1) If noted.
2) Drives display and outputs to zero when empty pipe detected.

10. Signal Interface (at Transmitter):
a. Analog Output:
1) Isolated 4 mA to 20 mA dc for load impedance from 0 ohm to at least 500 ohms minimum for 24V dc supply.
2) Supports Superimposed Digital HART protocol.
3) Ethernet IP communication protocol.
b. Discrete Outputs: If noted.
1) Two discrete outputs, typical, rated for up to 30 volts, typical.
2) Programmable as noted for the following typical parameters:
a) Totalizer pulse, high/low flow rates, percent of range, empty pipe zero, fault conditions, forward/reverse, etc.
c. Discrete Input: If noted.
1) Contact closure, configured as noted for the following typical parameters: reset totalizer, change range, hold output constant, drive output to zero, and low flow cutoff, etc.
d. Communication:
1) Ethernet IP communication as noted on drawings.

11. Cables:
a. Types: As recommended by manufacturer.
b. Lengths: As required to accommodate device locations.

12. Built-in Diagnostic System:
a. Features:
1) Field programmable electronics.
2) Self-diagnostics with troubleshooting codes.
3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
4) Initial flow tube calibration and subsequent calibration checks.

13. Factory Calibration:
a. Calibrated in an ISO 9001 and NIST certified factory.
b. Factory flow calibration system must be certified by volume or weight certified calibration devices.
c. Factory flow calibration system shall be able to maintain calibration flow rate for at least 5 minutes for repeatability point checks.

14. Factory Ready for Future In situ Verifications: If noted.
a. Original meter parameter values available from vendor by request.

15. Accessories:
a. In situ Verification System: If noted.
1) Quantity: One complete system provided for the project.
2) Verifies quantitatively that the meter and signal converter's present condition is the same as originally manufactured.
3) Physical access to the flow-tube not required.
4) Meet standards established by the National Testing Laboratory.
5) Tests and stores over 50-meter parameters related to primary coils, electrodes, interconnecting cable and signal converter.

6) Verification standard shall be plus or minus 1 percent of wet calibration for meters produced using the calibration verification service, or plus or minus 2 percent for standard meters.
7) Windows-based software.

b. Primary Simulation System: If noted.
1) Quantity: One complete system provided for the project.
2) Verifies proper operation of the signal converter by simulating the flow meter's output signal.
a) Generates pulsed dc excitation signal with a reference voltage of 70 mV.
b) Generated signal ranges from 0 to 99 percent (0 to 32.8 feet per second) with a resolution of 0.1 percent.
c) Switch selectable for forward, reverse and zero flow rate.
3) Verifies various input and output signals.

c. Spool Piece: Provide spool to match process pipe material and size for insertion into pipe line during meter maintenance or replacement, as noted.

16. Manufacturers:
a. Endress+Hauser Promag W400 Magnetic Flow Meter, 0xDN model, with Proline 400 transmitter with Ethernet IP communication protocol.

B. F16 Flow Element, Rotameter:
1. General:
a. Function: Indicate flow rate.
b. Type: Variable area; float and tapered tube.
2. Service Conditions:
a. Process Fluid: Water, unless otherwise noted.
b. Temperature Range:
1) Process Fluid: 33 degrees Fahrenheit to 250 degrees Fahrenheit.
2) Ambient: 32 degrees Fahrenheit to 125 degrees Fahrenheit.
c. Maximum Operating Pressure: As noted.
3. Performance:
a. Flowrate Range: As noted.
b. Accuracy: Plus or minus 2 percent of maximum flow, uncalibrated, over 12.5:1 turndown.
c. Repeatability: 0.5 percent of full scale.
4. Features:
a. Nominal Length: 10 inches.
b. Float Material: Type 316 stainless steel.
c. Tube: Borosilicate glass.
d. Seal:
1) Type: O-ring, unless otherwise noted.
2) Material: Buna-N, unless otherwise noted.
e. Polycarbonate operator protection shield.
f. Mounting: In line, unless otherwise noted.
g. Scales: Direct-reading external metal scale, unless otherwise noted.
h. Pressure Drop Design: Standard, unless otherwise noted.
5. Size and Process Connections:
a. Connection Size: As noted.
b. Tube Size: As noted.
c. Connection Material: Type 316 stainless steel, unless otherwise noted.

d. Connection Type: Threaded NPT, unless otherwise noted.
e. Connection Orientation: Vertical, unless otherwise noted.

6. Signal Interface: None, unless otherwise noted.
7. Manufacturers and Products:
   a. ABB; Series 10A4500.
   b. Emerson Process Management Brooks; Series 1100.
   c. Approved equal.

## 2.06 LEVEL COMPONENTS

A. L5 Level Element and Transmitter, Ultrasonic:
   1. General:
      a. Function: Continuous, noncontacting level measurement.
      b. Type: Ultrasonic.
      c. Parts: Element, transmitter, and interconnecting cable between element and transmitter.
   2. Service:
      a. Vapor Space Pressure: Atmospheric, unless otherwise noted.
      b. Operating Temperature Range:
         1) Element: Minus 40 to plus 150 degrees Fahrenheit.
         2) Transmitter: Minus 5 to 122 degrees Fahrenheit.
   3. Performance:
      a. Range: As noted.
      b. Zero Reference: As noted.
      c. Accuracy: Plus or minus 0.25 percent of maximum range or 6 mm, whichever is greater.
      d. Resolution: 2 mm or 0.1 percent of range, whichever is greater.
      e. Blanking Distance: As short as 1 foot.
   4. Element:
      a. Waterproof/weatherproof.
      b. Housing: Kynar, PVC, or Valox 357, unless otherwise noted.
      c. Face: Kynar, Teflon, Valox 357, unless otherwise noted.
      d. Process Connection: 8-inch flange, unless otherwise noted.
      e. Electrically Hazardous Rating: Unrated, unless otherwise noted.
      f. Beam Angle: 6 degrees or less.
      g. Integral temperature compensation.
      h. Sound Wave Frequency: 44 kHz, typical.
   5. Transmitter:
      a. Primary Configuration: Microprocessor based with keyboard operator interface.
      b. Secondary Configuration: Windows Based Configuration Software.
      c. Enclosure: NEMA 4X polycarbonate, unless otherwise noted.
      d. Power Supply: 115-volt, 50/60-Hz, unless otherwise noted.
      e. Isolated Analog Output:
         1) One, minimum, Milliamp current loop for load impedance of 0 to 750 ohms.
         2) Milliamp current loop programmable as 4-20, 0-20, 20-4, or 20-0 mA.
      f. Digital Communication: As noted.
      g. Other Features: As noted.
      h. Discrete Outputs: Minimum, five relays (combination of SPST and SPDT) rated for 5 amps continuous at 120V ac.

i. Display:
1) Multifield LCD.
2) High contrast 40 mm (1.5 inches).
3) In standard engineering units (feet, inches, or centimeters); volumetric conversion.
4) Alarm Messages: Loss of echo and cable circuit open or shorted.
j. Filters, Electronic:
1) For agitator blade echoes.
2) To remove small variations from surface waves.
3) Narrow echo and spike filters to remove spurious readings from noise sources such as variable frequency drives.
k. Various pump control features.

6. Interconnecting Cable: Weatherproof, UV protected, length as required, and type as recommended by manufacturer.
7. Manufacturers and Products:
a. Siemens; Model HydroRanger 200 with XPS15 transmitter.
b. Endress & Hauser; Model FMU-860.
c. Approved equal.

B. L30 Level Switch, Large Float, Nonmercury, Teflon Coated:
1. General:
a. Function: Actuate contact at preset liquid level.
b. Type: Direct-acting large float with enclosed switch and integral cable.
c. Large stainless steel float, Teflon coated.
d. Nonmercury switch.
2. Service: Water, wastewater, unless otherwise noted.
3. Performance:
a. Set Point: As noted.
b. Differential: 6.5-inch maximum.
4. Features:
a. Entire Assembly: Watertight.
b. Float Material and Size: Type 316 stainless steel, Teflon coated, minimum of 5-inch diameter.
c. Cable:
1) Combination support and signal.
2) Length: As noted or as necessary per mounting requirements.
3) Type 16 AWG, 3 wires (including ground).
d. Mounting: Pipe, unless otherwise noted or shown.
1) Pipe: Corrosion-proof cable clamp for 1-inch pipe.
2) Suspended: Cable/weight mounting kit including 15-pound anchor.
5. Connection Junction Box: If noted.
a. Fiberglass.
b. Connects up to four floats.
6. Signal Interface:
a. Switch:
1) SPST.
2) Normally open (NO) or normally closed (NC); as noted or as shown.
b. Contact Rating: 100 VA at up to 120 volts.
c. Type: Magnetic reed switch.
7. Intrinsic Safety Barrier: If noted: Requires 12-24V dc, 50 ma power source.

8. Manufacturer and Product:
    a. Anchor Scientific; Roto-Float SST-NM.
    b. Approved equal.

C. Level Switch, Solid State:
1. General:
    a. Function: Actuate relay contact at detected liquid level.
    b. Type: Solid State ultrasonic type.
    c. Integral electronic.
2. Service: Water, wastewater, any liquid unless otherwise noted.
3. Performance:
    a. Set Point: As noted.
    b. Repeatability: 2 mm (0.08") or better.
    c. Delay: 0.5 sec.
    d. Leakage Current: Less than 50 uA.
4. Features:
    a. Entire Assembly: Watertight.
    b. Material and Size: Type 316 stainless steel.
    c. Input Power: 6 to 24 Vdc.
    d. Sensor: 316 LSS.
    e. Temperature: -29 to 71°C (-20 to 160°F).
    f. Pressure: 316 SS Models: Up to 1000 psig (6895 kPa).
    g. Mounting: 3A NPT standard.
5. Intrinsic Safety Barrier: If noted.
6. Manufacturer and Product:
    a. Omega LVSW-701 Series.
    b. Approved equal.

## 2.07 MISCELLANEOUS COMPONENTS

A. M26 Hand Switch and Light, Corrosion, Round:
1. General:
    a. Function: Select, initiate, and display discrete control functions.
    b. Type: Heavy-duty, corrosion-resistant, industrial.
2. General Features:
    a. Mounting: 30.5 mm single round hole. Panel thickness 1/16 inch to 1/4 inch.
    b. Legend Plate: Standard size, square style laminate with white field and black markings, unless otherwise noted. Markings as shown, or as implied by P&IDs.
    c. Configuration: Light, pushbutton, or switch as noted or shown.
3. Light Features:
    a. Lights: 6V ac lamps and integral transformer for operation for operation from 120V ac, unless otherwise noted.
    b. Lens Color: Color as specified, noted, or shown.
    c. Push-to-test, unless otherwise noted.
    d. Additional: As noted.
4. Pushbutton Features:
    a. Operator: Single pushbutton, flush, unless otherwise noted.
    b. Color: Black, unless otherwise noted.
    c. Boot: None, unless otherwise noted.
    d. Contact Arrangement: As required or shown.

e. Additional: As noted.

5. Selector Switch Features:
   a. Operator: Knob, unless otherwise noted.
   b. Color: Black, unless otherwise noted.
   c. Boot: None, unless otherwise noted.
   d. Positions: As required or shown.
   e. Return: Manual, unless otherwise noted.
   f. Contact Arrangement: As required or shown.
   g. Additional: As noted.
6. Signal Interface:
   a. Contact Block:
      1) Type: Standard, unless otherwise noted.
      2) Materials: Silver amalgam, unless otherwise noted.
      3) Rating: 10 amps continuous at 120V ac, unless otherwise noted.
      4) Sequence: Break-before-make, unless otherwise noted or shown.
      5) Arrangement: Normally open or normally closed as shown, or to perform the functions noted.
7. NEMA Rating: NEMA 4, watertight, dust-tight, and NEMA 4X, corrosion-resistant.
8. Manufacturers and Products:
   a. Allen-Bradley; Bulletin 800H.
   b. Square D Co.; Class 9001, Type SK.
   c. Eaton Corp.; Cutler-Hammer, Type E34.

B. M30 Horn, Indoor/Outdoor:
1. General:
   a. Function: Audible alarm. Produces sound by electro-mechanical vibration of a diaphragm.
2. Performance:
   a. Temperature, Operating: Minus 65 degrees Fahrenheit to 150 degrees Fahrenheit.
   b. Sound Output Level: 100 dB nominal at 10 feet (110 dB at 1 meter).
3. Features:
   a. Dimensions: 4-3/8 inches in height and width, and 2.5 inches in depth, for horn and enclosure.
   b. Body: Die-cast zinc.
   c. Diaphragm: Stainless steel.
   d. Projector: None, unless otherwise noted.
   e. Listings: UL, cUL listed, FM, CSA approved.
4. Enclosure:
   a. Type: Cast aluminum with neoprene-gasketed NEMA 4X housing.
   b. Mounting: Surface mount.
5. Power: 120V ac, 50/60-Hz, unless otherwise noted.
6. Manufacturer: Federal Signal Corp.; Model 350WB.

C. M31 Warning Light, Indoor/Outdoor:
1. General:
   a. Function: Visual alarm.
   b. Type: Rotating reflector or flashing bulb.
   c. Parts: Light and spare bulbs.

2. Performance:
    a. Temperature, Operating: Minus 35 degrees Fahrenheit to 190 degrees Fahrenheit.
    b. Flash Rate: Nominally 90 per minute.
3. Features:
    a. Dome: Polycarbonate.
    b. Dome Color: Amber, unless otherwise noted.
    c. Lamp Life: 200 hours.
    d. Lamp: Incandescent/25 watts.
4. Enclosure:
    a. Type: IP65 (NEMA 4X).
    b. Mounting: 1/2-inch pipe, unless otherwise noted.
    c. Listing: UL listed, CSA certified.
5. Power: 120V ac, 50/60-Hz.
6. Spare Bulbs: Provide two for each light.
7. Manufacturers: Federal Signal; Model 225.

## 2.08 PRESSURE COMPONENTS

A. P4 Pressure Gauge:
    1. General:
        a. Function: Local pressure indication.
        b. Type: Bourdon tube element.
    2. Performance:
        a. Scale Range: As noted.
        b. Accuracy: Plus or minus 0.50 percent of full scale.
    3. Features:
        a. Dial: 4-1/2-inch diameter.
        b. Pointer Vibration Reduction: Required, unless otherwise noted. Use the following method.
            1) Liquid filled gauge front, unless otherwise noted.
                a) Glycerine fill, unless otherwise noted.
        c. Case Material: Black thermoplastic, unless otherwise noted.
        d. Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components):
            1) Stainless steel, unless otherwise noted.
        e. Pointer: Adjustable by removing ring and window.
        f. Window: Glass or acrylic, unless otherwise noted.
        g. Threaded reinforced polypropylene front ring.
        h. Case Type: Solid front with blow-out back.
    4. Process Connection:
        a. Mounting: Lower stem, unless otherwise noted.
        b. Size: 1/2-inch MNPT, unless otherwise noted.
        c. Diaphragm Seal: Pressure Gauge shall be provided with factory assembled Diaphragm Seal.
    5. Accessories:
        a. Throttling Device: Required, unless otherwise noted.
            1) Type suitable for the intended service.
            2) Install in gauge socket bore.
    6. Manufacturers and Products:
        a. Ashcroft; Duragauge Model 1259/Model, 1279/Model, 1279 PLUS!

b. Ametek U.S. Gauge; Solfrunt Model 19XX/1981Advantatge.
c. WIKA, Type 2XX.34.

B. P5 Differential Pressure Gauge:
1. Type:
a. Bourdon tube actuated pressure gage.
b. Differential pressure operation, as indicated on the loop drawings.
2. Functional/Performance:
a. Accuracy - Plus or minus 1.0 percent of span or better.
3. Physical:
a. Case - Phenolic shock resistant or 316 stainless steel for surface/stem mounting with a pressure relieving back. The case shall be vented for temperature/atmospheric compensation. Gage shall be capable of being liquid filled in the field or at the factory.
b. Window - Clear acrylic or shatter proof glass.
c. Bourdon Tube - 316 stainless steel.
d. Connection - 1/4-inch NPT, unless otherwise noted.
e. Gage size - 4.0-in minimum.
f. Pointer travel - Not less than 200 degrees nor more than 270 degree arc.
g. Range - As indicated in the instrument device schedule.
4. Accessories/Options Required:
a. Shutoff valve - Each gage shall have a process shutoff valve which can also be used as an adjustable pressure snubber.
b. Special scales - Engineer reserves the right to require special scales and/or calibration if the manufacturers standard is not suitable for the application.
c. Gauges listed as liquid filled in the instrument device schedule shall be Glycerin filled. The liquid filled gauges shall be glycerin filled at the factory.
5. Manufacturers:
a. Dwyer - Series 2000 Magnehelic.
b. Ashcroft - Series 1131.
c. Approved equal.

C. P6 Pressure Seal, Diaphragm:
1. General:
a. Function: Isolate sensing element from process fluid.
b. Type:
1) Diaphragm.
2) Fluid filled between diaphragm and sensing element.
2. Service:
a. Pressure: Same as associated sensor.
b. Temperature Range: If noted.
3. Performance:
a. Pressure:
1) For threaded process connections, at least 2,500 psig at 100 degrees Fahrenheit.
2) Glycerin Fill: Suitable only for pressure (not vacuum applications).
b. Temperature:
1) Dependent upon fill fluid.
a) Glycerin (food grade): Zero to 400 degrees Fahrenheit.

b) Silicone: Minus 40 degrees Fahrenheit to plus 600 degrees Fahrenheit.
c) Silicone (food grade): Zero to 375 degrees Fahrenheit.
d) Halocarbon: Minus 70 degrees Fahrenheit to 300 degrees Fahrenheit.

4. Features:
   a. Materials:
      1) Lower Housing: Type 316 stainless steel, unless otherwise noted.
      2) Diaphragm Material: Type 316 stainless steel, unless otherwise noted.
      3) Top Housing: Steel, unless otherwise noted.
   b. Diaphragm: Welded to upper housing, unless otherwise noted.
   c. Filling screw in upper housing.
   d. Fill Fluid:
      1) As noted.
      2) Or approved equal.
      3) Factory assembled and filled.
   e. Flushing Connection: 1/4-inch NPT in lower housing.
   f. Diaphragm Seal Displacement: 0.1 cubic inch, nominal.
5. Connections:
   a. Instrument: 1/2-inch female NPT, unless otherwise noted or shown.
   b. Process: 1/2-inch female NPT, unless otherwise noted or shown.
6. Manufacturers:
   a. Ashcroft; Type 201.
   b. Ametek; Mansfield and Green Division; Type SG.
   c. WIKA; Type L990.10.

D. P7 Pressure Switch, Adjustable Dead Band:
1. General:
   a. Function: Monitor pressure, activate switch at set point, and deactivate switch at reset point.
   b. Type:
      1) Piston-actuated.
      2) Both set point and dead band (the differential between set point and reset point) adjustable.
2. Performance:
   a. Set Point:
      1) As noted.
      2) Repeatability: Plus or minus 1 percent of range.
   b. Reset Point: As noted.
   c. Range: The noted set point shall fall between 20 percent and 80 percent of the range.
   d. Deadband: Adjustable within nominally 25 percent and 85 percent of range.
   e. Overpressure Proof Pressure:
      1) Pressure psi Ranges: At least 400 percent of rated maximum static pressure.
      2) Pressure Inches of Water Ranges: 20 psig.
      3) Compound Range: 250 psig.
      4) Vacuum Range: 250 psig.

f. Operating Temperature Range:
1) Dependent on actuator seal materials.
2) For Buna-N seal, 0 degrees Fahrenheit to 150 degrees Fahrenheit.

3. Features:
a. Actuator Seal: Buna-N, unless otherwise noted.
b. Adjustable dead band.
c. Mounting: Surface, unless otherwise noted.

4. Process Connection:
a. 1/4-inch NPT female connections, unless otherwise noted.
b. Materials:
1) Pressure psi Ranges: Type 316 stainless steel, unless otherwise noted.
2) Pressure Inches of Water Ranges: Epoxy coated carbon steel, unless otherwise noted.
c. Diaphragm Seal: Pressure Switch shall be provided with factory assembled Diaphragm Seal.

5. Enclosure: NEMA 4X, unless otherwise noted.

6. Signal Interface:
a. Contact Type:
1) SPDT.
2) Rated for 10 amps minimum at 120V ac.
b. Hermetically Sealed Switch: If noted.

7. Manufacturers and Products:
a. Ashcroft; L or P Series.
b. United Electric; J6 Series.
c. If NEMA 7, explosion-proof enclosure specified; Ashcroft; P Series only.

E. P8 Pressure Switch, Fixed Deadband:
1. General:
a. Function: Monitor pressure.
b. Type: Diaphragm actuated switch.

2. Performance:
a. Set Point:
1) As noted.
2) Repeatability: Plus or minus 1 percent.
b. Range: Noted set point shall fall between 20 percent and 80 percent of range.
c. Overpressure Proof Pressure: At least 400 percent of rated maximum static pressure.
d. Operating Temperature Range:
1) Dependent on actuator seal materials.
2) For Buna-N seal, 0 degrees Fahrenheit to 150 degrees Fahrenheit.

3. Features:
a. Actuator Seal: Buna-N, unless otherwise noted.
b. Differential (dead band): Fixed.
c. Reset: Automatic, unless otherwise noted.
d. Mounting: Surface, unless otherwise noted.

4. Process Connection:
a. 1/4-inch NPT female connections, unless otherwise noted.
b. Materials: Nickel-plated brass, unless otherwise noted.

c. Diaphragm Seal: Pressure Switch shall be provided with factory assembled Diaphragm Seal.

5. Enclosure: NEMA 4X.
6. Signal Interface:
   a. Contact Type:
      1) SPDT, unless otherwise noted.
      2) Rated for 10 amps minimum at 120V ac.
   b. Hermetically Sealed Switch: If noted.
7. Manufacturers and Products:
   a. Ashcroft; Type 400, B Series.
   b. United Electric; 400 Series.

F. P15 Pressure Seal, Annular:
1. General:
   a. Function:
      1) Sense pressure in a process line and transfer to pressure monitoring device.
      2) Protect attached pressure monitoring device from sludge or slurry.
   b. Type: Annular fluid-filled device that senses pressure through flexible sleeve around full pipe circumference.
2. Performance:
   a. Operating Conditions: Suitable for line pressures up to pipe flange rating.
3. Features:
   a. Construction:
      1) In-line, 8 Inches and Smaller: Full-faced thru-bolted with outside diameter same as mating flanges, unless otherwise noted.
      2) In-line, 10 Inches and Larger: Wafer style.
      3) Offline: Threaded, unless otherwise noted.
   b. Materials:
      1) Body: Carbon steel, unless otherwise noted.
      2) Flanges (where applicable): Carbon steel, unless otherwise noted.
      3) Flexible Sleeve: Buna-N, unless otherwise noted.
      4) Fill Fluid: Ethylene glycol/water or propylene glycol, unless otherwise noted.
   c. Factory Filled System:
      1) Filled and assembled with pressure monitoring device(s).
      2) Coordinate attached pressure monitoring device(s) with system integrator. Seal vendor's standard pressure monitoring device(s) only acceptable if it meets specification of the related pressure monitoring device.
4. Process Connections:
   a. Mounting: In-line or offline, as noted or shown.
   b. Pipe Size:
      1) In-line: As noted or shown.
      2) Offline: 2 inches, unless otherwise noted.
   c. Connections:
      1) In-line, Full-faced through-bolted: ASME B16.5, 150-pound flanges.
      2) In-line, Wafer style: Compatible with Classes 150/300 flange drilling.
      3) Offline: Female NPT Threaded, unless otherwise noted.
5. Manufacturers and Products:
   a. Red Valve Company; Series 40, Series 42/742, Series 48.

b. Dover/OPW Engineered Systems; Iso-Ring.

## 2.09 SECONDARY COMPONENTS

A. S12 Indicator, Field Mount:
   1. General:
      a. Function: Digital indication of analog signal.
      b. Type:
         1) Integral enclosure suitable for field mounting.
         2) Loop-powered.
   2. Performance:
      a. Accuracy: Plus or minus 0.1 percent of full scale plus or minus one count.
      b. Display Update Rate: 2.5 second minimum.
      c. Operating Temperature Range: Minus 40 degrees Celsius to 80 degrees Celsius.
   3. Features:
      a. Display:
         1) LCD.
         2) 3.5-digits.
         3) 0.35 inch minimum.
      b. Input Impedance: 75 ohms maximum.
   4. Enclosure:
      a. NEMA 4X, unless otherwise noted.
      b. Mounting: Surface, unless otherwise noted.
   5. Loop-powered.
   6. Signal Interface: 4 to 20 mA dc at 24V dc maximum.
   7. Accessories: As required to support the noted options.
   8. Manufacturers and Products:
      a. Newport Electronics, Santa Ana, CA; Model 508B.
      b. Precision Digital, Natick, MA; Model Trident Model PD660/661.

B. S24 Isolator, Current:
   1. General:
      a. Function: Isolate an analog current signal.
      b. Type:
         1) Solid state with external power supply.
         2) Three-way isolation of the input signal, output signal, and external power supply.
      c. Parts: Isolator plus DIN rail strip.
   2. Performance:
      a. Isolation:
         1) Three-way isolation between input, output, and power circuits for common mode voltages up to 250V ac, or 354V dc of ground, on a continuous basis.
         2) Able to withstand 1500Vac dielectric strength test for 60 seconds without breakdown.
      b. Output Ripple: Less than plus or minus 0.1 percent of maximum output span.
      c. Accuracy: Plus or minus 0.1 percent of output span.

d. RFI Resistance: Less than plus or minus 0.5 percent of output span with RFI field strengths of up to 10V/meter at frequencies of 27, 151, and 467 MHz.
e. EMI resistance: Less than plus or minus 0.25 percent of output span effect with switching solenoids or commutator motors.
f. Ambient Temperature, Operating: Minus 13 degrees Fahrenheit to plus 185 degrees Fahrenheit.

3. Features:
4. a. Zero and span trim adjustments using 15-turn potentiometers.
   b. Calibration independent of load.
5. Signal Interface:
   a. Input:
      1) 4 to 20mA dc.
      2) Impedance: 75 ohms.
   b. Output :
      1) 4 to 20 mA dc.
      2) Drives output load impedance up to 1050 ohms independent of supply voltage to isolator.
6. Enclosure:
   a. NEMA 1, unless otherwise noted.
   b. Mounting: DIN Rail, unless otherwise noted.
7. Power: 115Vac, unless otherwise noted.
8. Accessories: 3-inch Type T DIN rail strip.
9. Manufacturer:
   a. Acromag Model Flat Pack 330I/430I Isolators.
   b. Rochester Model SC-1302 Voltage/Current Transmitter.
   c. AGM Model PTA 4000.

## 2.10 SYSTEM COMPONENTS

A. Y50 Programmable Control (Large Size, 120V ac):
   1. Programmable Controller: The programmable controller shall consist of central processor, memory, input/output, interconnecting cables, and optional items as specified:
      a. General Specifications:
         1) Operating Temperature: 0 to 60 degrees Celsius.
         2) Humidity: 5 to 95 percent noncondensing.
         3) Operating Voltage: 120 volts, 60-Hz (plus or minus 10 percent).
         4) Maximum Scan Time (Ladder Logic): 3 mS per 1,000 words.
      b. Central Processor:
         1) The central processing unit, CPU, shall be, as a minimum, a 32-bit microprocessor that provides system timing, performs online diagnostics, and processes the user program. The CPU shall be capable of performing the same functions as a conventional analog and relay logic system, including PID controllers, relays, timers, counters, shift registers, and drum sequencers. The CPU shall also be capable of data word functions such as four-function integer math, data shift registers, data word move, data file compare with pointer, and Ale move.

2) The CPU shall sample the discrete and analog input/output system, including internal discrete and word values. The CPU then processes the I/O with the user program stored in ladder memory, then controls the outputs based on the results of the logic operation. The CPU shall execute the user program by rapidly scanning the ladder memory. Both logic and word type functions are executed in the order they appear in the program. Each ladder lung is processed, then the results of that rung shall be available to the next logic rung.
3) The CPU shall perform online diagnostics that monitor the internal operation of the programmable control. If a failure is detected, the CPU shall initiate an orderly system shutdown. As a minimum, the CPU shall monitor the following system failures and initiate a system shutdown if a failure occurs.
    a) Memory failure.
    b) User program longitudinal redundancy error.
    c) Memory battery low.
    d) Input/output subsystem error.
    e) Watchdog timer time out.
4) Memory:
    a) The programmable control memory shall consist of the following functional types of memory:
        (1) Ladder logic program memory.
        (2) Analog processor memory.
        (3) Variable data memory.
        (4) Input/output data memory.
        (5) Miscellaneous.
    b) The memory shall be read/write random access memory (RAM) with an integral battery backup that will maintain the memory for a minimum of 30 days with no external electrical power. The memory provided shall be user configurable from the programming unit.
5) Communication Ports:
    a) As a minimum provide the following communication ports for each PLC:
        (1) One port for connection to lap top programmer.
6) The programmable controller shall be Allen-Bradley family, match to existing or latest model at the time of the construction if approved by the engineer.

2. PLC I/O Subsystem:
    a. Input/Output: The input/output subsystem shall consist of all of the hardware for the CPU to communicate with the specified types of input and output modules. Provide remote I/O rack configuration where specified:

b. Discrete Input Modules:
    1) Switch contact input modules. Switch contact input modules shall be capable of supporting Dry Contact inputs (minimum duration 100 mS). The PLC shall provide at least 24V d.c. wetting power to the field contacts. The wetting power shall be isolated from the PLC internal power. The module inputs shall be optically isolated from the PLC and designed to withstand transients and surges without damage. Input components shall be individually protected to ensure that failure within one component will not interrupt processing of others. Input circuits shall be protected up to 175 V. AC RMS fault. Light emitting diodes, (LED's), one adjacent to each pair of input terminals, shall be provided to indicate a closed contact condition.
    2) The digital input modules shall be Allen-Bradley match to exsitng.
c. Discrete Outputs:
    1) Switch Contact Output Modules. Switch contact output modules shall be capable of providing dry-contacts in either momentary (pulsed), or latched (sustained) mode to control AC or DC powered loads. All DC output circuits shall incorporate current limiting and, for DC powered loads, switching spike suppression diodes. Contact outputs shall be rated to 5 amps at 120 V AC minimum. The output failure mode shall be selectable so that upon station or communication system failure all outputs would be placed in the nonconducting mode, or remain as they were prior to failure. Isolation resistance shall be 1,000 ohms minimum at 300 V. DC between any set of field terminals and any other set or earth ground. Isolation voltage shall be 500 V. AC RMS minimum between any set of field terminals and any other set or earth ground. Light-emitting diode status indication shall be provided adjacent to each contact output to indicate a closed contact condition.
    2) The number and type of output module shall be as shown on the Drawings.
    3) The digital output module shall be Allen-Bradley match to existing.
d. Analog Input, isolated differential: The analog input Module shall be suitable for accepting a 4 to 20 mA dc signal. The input shall have an accuracy of plus or minus 5 percent of full scale. The input shall be capable of withstanding low common mode transients of 1,500 volts peak without catastrophic PLC failure. Analog input modules shall be Allen-Bradley match to existing.
e. Analog Output, Nonisolated, Single Ended: The analog outputs shall. be 4 to 20 mA outputs suitable for driving into a 0 to 600 ohm load with an accuracy of plus or minus 5 percent of full scale. Analog output modules shall be Allen-Bradley match to existing.

3. Upgrade PLC firmware to the latest available at the time of startup.

B. Y58 Ethernet Fiber-To-Copper Transceiver:
1. Function: Convert fiber optic Ethernet signal (100 Base-FX) to copper signal (10/100 Base-TX).
2. Features:
    a. Fiber Optic Connectors: Coordinate.
    b. Copper Connector: RJ45.
    c. Power: 10 to 30V dc.

d. Mounting: DIN-rail.

3. Performance:
   a. IEEE Compliance: Full 802.3.
   b. EMI Emissions and Safety: FCC Part 15A, UL 1604, Class 1, Division 2, Groups B, C, D.
4. Manufacturer and Product:
   a. N-TRON.
   b. BlackBox.
   c. Or equal.

C. Y81A Network Switch, Ethernet:
1. Full compliance with IEEE 802.3.
2. Supports Ethernet (10BASE-TX), Fast Ethernet (100BASE-TX/FX) and Gigabit Ethernet (1000BASE-TX/FX) networking technologies.
3. Wire-speed switching fabric.
4. Ports:
   a. 10/100/1000 Base TX: Quantity as shown on block diagram plus 3 spare.
      1) RJ 45 sockets.
      2) Auto crossing.
      3) Auto negotiating.
      4) Auto polarity.
      5) Full duplex capable.
   b. 1000 Base FX: Two, minimum.
      1) SC sockets.
      2) Multimode cable.
         a) Compatible with 50/125 micron and 62.5/125 micron fibers.
      3) Full duplex capable.
      4) 8 dB link budget at 1,300 nm.
5. Network Topology:
   a. Star.
   b. Ring with HIPER-Ring.
   c. RSTP.
6. Management: Serial interface, web interface, SNMP v1, v2, v3.
7. Diagnostics:
   a. LEDs (Power, Link Status, Data, Fault, redundancy manager).
   b. RMON (statistics, history, alarms, events).
   c. Port mirroring.
   d. Topology detection 802.1ab.
8. Configuration: Terminal software, BootP, DHCP, DHCP Option 82.
9. Security:
   a. Port security (MAC based and IP based).
   b. SNMP V3.
10. Other Services:
    a. Port prioritization (IEEE 802.1D/p).
    b. VLAN (802.1Q).
    c. Multicast (IGMP Snooping/Queier, GMRP).
    d. Broadcast limiter.
    e. Flow Control (IEEE 802.3x SNTP).
11. Redundancy:
    a. HIPER-Ring (ring structure).
    b. RSTP.

c. Redundant net/ring coupling.
d. Dual Homing.
e. Redundant 24-volt power supply.

12. Power:
    a. Panel mount: 24V dc, 375 ma max.
    b. Rack mount: 120V AC.
13. Operating Temperature: 0 to 60 degrees C.
14. IEC 60068-2-27 Shock: 15g, 11 ms duration, 18 shocks.
15. IEC 60068-2-6 Vibration:
    a. 1 mm, 2 to 13.2-Hz, 90 minutes.
    b. 0.7g, 13.2 to 100-Hz, 90 minutes.
    c. 3.5 mm, 3 to 9-Hz, 10 cycles, 1 octave/minute.
    d. 1g, 9 to 150-Hz, 10 cycles, 1 octave/minute.
16. Approvals: cUL 508 (E175531), cUL 1604 Class I Div 2 (E203960), cUL 60950 (E168643).
17. Spares: Provide a spare switch that is identical to provided one.
18. Manufacturer, model:
    a. Rack Mounted Network switch:
        1) Hirschman, MACH-104-XXTX-F. XX=20 or more depending on quantity of ports required.
    b. Panel mount managed:
        1) Hirschman, RS20-XX00M2M2SDAEHH. XX=08 or 16 depending on quantity of ports.
        2) Allen Bradley Stratix 5700 2500 where ring level redundancy required.
    c. Panel Mount Unmanaged:
        1) N-TRON 108TX where 8 ports required or 105TX where 5 ports reguired.
    d. All switches to be same revision

D. Y174A, Panel-Mounted Touch Screen Operator Interface Computer:
1. General: Industrial PC with integral touchscreen display for mounting on front of control enclosure.
2. Features:
    a. CPU: Intel® Dual Core™ i5-7300U, 2.6 GHz.
    b. Memory: 8 GB.
    c. Storage: 256 GB SSD.
3. Ports:
    a. LAN: 2 x GbE RJ-45.
    b. Serial: 1 x RS-232/422/485 DE-9P, COM1 (default RS-232), 3 x RS-232 DE-9P, COM2/COM3/COM4.
    c. USB: 4 x USB 3.0 type A, 2 x USB 2.0 type A.
    d. External Display Ports: 1 x DisplayPort 1.2, 1 x HDMI® 1.4a
4. Display:
    a. Type: TFT FHD LCD.
    b. Backlight Life: 50,000+ hours.
    c. Contrast Ratio: 3000:1.
    d. Luminance: 250 cd/m2.
    e. Maximum colors: 16.2 M.
    f. Maximum resolution: 1920 x 1080.
    g. Size: 21.5” Widescreen.

5. Touchscreen:
    a. Interface: USB.
    b. Type: Projected Capacitive Touch.
6. Environment:
    a. Ingress Protection: Front panel, NEMA 4.
    b. Operating Temperature: 0 to 60 degrees C.
7. Construction:
    a. Chassis: Black Steel Chassis, Aluminum Heatsink.
8. Software:
    a. Operating System: Microsoft Windows© 10 IoT Enterprise Embedded 2019 LTSC 64-bit (EPKEA).
9. Power Input: 9~24 VDC, 51 W.
10. Manufacturer and Product:
    a. Hope Industrial Systems, HIS-ML23-STAD with Dell OptiPlex 5090 micro PC is acceptable.
    b. Provide model current at time of purchase with equal or superior function and performance.

E. Y41 Uninterruptible Power Supply System, Tower:
1. General:
    a. Function: Provides backup power and power regulation for workstations and peripherals.
2. Performance:
    a. Capacity: 1.4 kVa, minimum.
    b. Input Power:
        1) 120V ac single phase, 60-Hz, unless otherwise noted.
        2) Connections: Manufacturer's standard, unless otherwise noted.
    c. Output Power:
        1) 120 V ac single-phase, 60-Hz, unless otherwise noted.
        2) Connections: Manufacturer's standard, unless otherwise noted.
    d. Backup Runtime:
        1) Full Load: 5 minutes, minimum.
3. Features:
    a. Topology: Line-Interactive.
    b. Transfer Time: 6 ms, maximum.
    c. Diagnostics: Full system self-test on power up.
    d. Communication Port: USB and serial port, minimum.
    e. UL Listed.
    f. Warranty: 2 years.
    g. Surge Suppression: Manufacturer Standard.
4. Accessories:
    a. Software: Manufacturer standard software.
    b. Provide power cables as required.
5. Manufacturer and Model: Eaton 5P 1500 Tower.

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## SECTION 46_36_44

## LIME SLAKING SYSTEM

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes: Lime slaking/feed system with appurtenances.

B. Existing lime system (reference only):
   1. Slaker System Design.
      a. Location:
         1) Chemical Building.
            a) Type: volumetric feeder, paste slaking, auger-type grit remover, slurry tanks with mixer.
         2) Capacity (each unit): 2000 lb/hr of quicklime.

C. Proposed System Design (general criteria).
   1. Slaker System Design.
      a. Location:
         1) Chemical Building.
            a) Type: volumetric feeder, paste slaking, conveyor-type grit remover, slurry tanks with mixer.
         2) Capacity (each unit): 2000 lb/hr of quicklime.
         3) Existing slurry tanks/mixer system to remain in service.

## 1.02 REFERENCES

A. American Bearing Manufacturers' Association (ABMA).

A. American Institute of Steel Construction (AISC).
   1. 360 – Specification for Structural Steel Buildings

B. American National Standards Institute (ANSI).

C. American Society of Mechanical Engineers (ASME):
   1. A13.1 – Scheme for the Identification of Piping Systems.

D. American Welding Society (AWS):
   1. A2.4 - Standard Symbols for Welding.
   2. D1.1 - Structural Welding Code-Steel.

E. ASTM International (ASTM):
   1. A 36 - Standard Specification for Carbon Structural Steel.
   2. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

4. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
5. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
6. A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
7. A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
8. B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

F. American Water Works Association (AWWA):
1. B202 - Standard for Quicklime and Hydrated Lime.
2. D103 - Standard for Factory-Coated Bolted Steel Tanks for Water Storage.

G. Institute of Electrical and Electronics Engineers (IEEE):
1. 841 - Standard for Petroleum and Chemical Industry--Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors--Up to and Including 370 kW (500 hp).

H. International Society of Automation (ISA):
1. 5.4 – Instrument Loop Diagrams.

I. International Organization for Standardization (ISO):
1. 9001 - Quality Management Systems.

J. National Electrical Code (NEC):
1. Article 310 – Conductors for General Wiring.
2. Article 430 – Motors, Motor Circuits, and Controllers.

K. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
2. AB 1 – Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
3. MG-1 – Motors and Generators.

L. National Fire Protection Association (NFPA):
1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.
2. 780 - Standard for the Installation of Lightning Protection Systems.

M. Occupational Safety and Health Administration (OSHA).

N. SAE International (SAE):
1. 1045 - Predicting the Contact Conditions for Hypoid Gear Sets By Analysis and a Comparison With Test Data.

O. Underwriters Laboratories, Inc. (UL):
   1. 96A - Installation Requirements for Lightning Protection Systems.
   2. 508 - Industrial Control Equipment.
   3. 508A – Industrial Control Panels.
   4. 508C - Standard for Power Conversion Equipment.

P. United States Environment Protection Agency (EPA).
   1. NSF 60– Drinking Water Chemicals.
   2. NSF 61 – Drinking Water System Components.
   3. NSF 372 – Low Lead Content.

## 1.03 DEFINITIONS

A. Supplier or Lime System (LS) Supplier: A manufacturer, fabricator, distributor, material, man or vendor with whom Contractor will enter into a contract with to supply equipment and services as specified in this Section.

B. Contractor: An entity or organization experienced with the installation of water treatment equipment who will procure, install, test, and place into successful operation the equipment specified.

C. Lime: This Section uses the term "lime" to refer to quick lime that will be slaked into a usable lime slurry product for dosing into the existing solids contact clarifiers (SCCs).

D. NEMA Type 4X enclosure in accordance with NEMA 250.

## 1.04 SCOPE

A. Scope:
   1. Lime System Supplier:
      a. Shall supply equipment pre-piped and pre-wired to the maximum extent possible to minimize the amount of on-site installation work required.
      b. Shall supply for installation by Contractor, lime system components specified in Section 2.05A and summarized below. The lime storage and feed system shall generally include but not be limited to, the following major components:
         1) Lime Slakers, complete with water supply panel system, volumetric feeders, grit removers and related appurtenances needed for system operation.
         2) Remote-Mounted Relay Logic Bases Slaker Control Panel.
         3) Miscellaneous Instrumentation and Accessories.
      c. Supplier shall coordinate all slaking and appurtenance equipment as a complete integrated package, with a single responsibility for proper function of related equipment; including all of the items listed above.
      d. Only with written approval of the County or Engineer can the Lime System supplier delegate the responsibility of supplying the equipment above. This shall not relieve the Lime System Supplier from providing a fully operating lime system.
      e. The Work also includes coordination of design, assembly, testing, and installation of all equipment associated with this Section.

f. Lime System supplier shall coordinate with Instrumentation Integrator to provide all necessary information for Plant SCADA integration. The Instrumentation Integrator may need these information for control and monitoring features to the Plant SCADA.

2. Contractor:
   a. Shall provide in general, but not limited to, all other scope of supply as part of the work not furnished by Supplier but required for operation, including labor, equipment, materials, tools, utilities, and incidentals required to facilitate the installation, testing, and start-up of the lime system components. This shall generally include, but not be limited to, the following:
      1) Demolition and disposal of all equipment scheduled for demolition, and protection of equipment remaining in service during demolition.
      2) All labor, materials, equipment, supports, and incidentals required to install items shipped loose by Supplier for installation by Contractor.
      3) Potable and utility water piping, valves, backflow prevention, hose bibs, connections and all incidentals.
      4) Mounting and installing all field instruments
      5) 480 volt, 3 phase, 60 hertz power: All electrical power and associated disconnects and appurtenances required for lime feed system.
      6) Field power and control wiring of all Supplier provided control panels, motors, equipment, control devices, including all conduit, wire, fittings, junction boxes, etc. required for a complete and working system.
      7) Fabrication and installation of Supplier designed supports for Supplier provided components and control panels.
      8) SCADA: All labor, materials, and equipment required to incorporate the specified lime storage and feed equipment into the plant control system.
      9) Coating systems: all labor, materials, and equipment necessary for the field coatings required for the lime system as detailed in Section 09_96_01 - High Performance Coatings.
   b. The Work also includes coordination of design, assembly, testing, and installation of all equipment associated with this Section.

## 1.05 SUBMITTALS

A. Procedures: As specified in Section 01_33_00 – Submittal Procedures.

B. Submit for approval the following:
   1. Shop drawings:
      a. General:
         1) Drawings shall contain all information required by Contractor for the detailed design and location of all connecting or adjacent structural and mechanical items, such as connections and supports to existing and new foundations, anchor bolts, steel supports, piping, conduit, etc.
      b. Dimensional drawings showing general arrangement of the new slakers and connected equipment, piping, control panels, etc. at the site.

c. Assembly and installation drawings and details indicating exact dimensions, thicknesses, elevations, and materials of construction for all components.
    1) Drawings shall indicate location, type, and size of all field welds for equipment.
    2) Drawings shall indicate size, type, and arrangement of all anchor bolts associated with the equipment.
d. Nameplate data for each piece of equipment.
e. Shop drawings shall be based on field verified, project specific dimensions and installation requirements.

2. Calculations:
    a. Provide calculations indicating size, design, and quantity of anchor bolts and orientation of bolts for each slaker, pump, and slurry tank under the action of dead, live, wind, seismic, and other loads specified and contain an appropriate safety factor.
    b. Provide structural calculations indicating structural loads on structural steel supports for mixers on tanks and dust collectors under the action of dead, live, seismic, and other loads specified and contain an appropriate safety factor.
    c. Structural calculations shall be signed and sealed by a professional engineer registered in the State of Florida.
3. Product data:
    a. Manufacturer's standard literature, illustrations, specifications, and engineering data for all components including total weight of each major component, connection details, and performance data.
        1) Excise or cross out non-applicable information and clearly mark applicable information with citations to and terminology constant with this Section.
        2) Clearly indicate the model number, materials, and all features selected for each piece of equipment or component.
    b. Provide a complete listing of spare parts including part number, and contact name, address, and telephone number of nearest and all manufacturer service centers where parts can be obtained. If the County desires to purchase spare parts, a list of current pricing shall be provided.
        1) Submit a list of parts recommended by the manufacturer to be replaced after 1 and 3 year(s) service and any special tools for each type of equipment furnished including special tools necessary for adjustment, operation, maintenance, and disassembly.
    c. Provide a complete listing of all lubrication materials required including quantities, type, and name and model number of manufacturer.
    d. Manufacturer’s installation instructions including recommendations for field welding and welding passivation, installation tolerances, start-up, and troubleshooting.
    e. Protective coatings. Provide manufacturers data sheet on all coatings indicating thicknesses, recommended cure times, recommended application methods and composition of protective coating.
    f. Provide drawings of each nameplate.
4. Data and reports:
    a. Submit resume of qualified field technician for Contractor's approval.
    b. Submit factory acceptance test of control panel for Contractor's approval.
    c. Submit field acceptance test results to Contractor.

d. Submit performance guarantee to Contractor for approval.
e. Submit data and report of performance testing of lime feed equipment.

C. Control and Instrumentation System:
1. Provide submittals as specified in Division 40, including but not limited to the following:
a. Hardware submittal:
1) Detailed bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for all field-mounted devices or assemblies, control panel assemblies, and internal control panel components.
2) Calculations:
a) Include derating for temperature and elevation as necessary.
3) Technical brochures or bulletins for all field instruments specified in this Section in addition to separate technical brochures or bulletins.
4) Catalog cuts for all process control and instrumentation equipment.
5) Control panel heating/cooling calculations.
6) Complete grounding requirements for each system component.
7) Requirements for physical separation between control system components and 24 VDC, 120 VAC, and 480 VAC power cables.
8) A price list of recommended spare parts covering items which are furnished under this Contract with the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
9) Calibration, adjustment, and test details for all control system components.
b. Shop drawings:
1) A complete set of control system drawings which depict:
a) County project name and number.
b) Instrument and control panel installation, mounting, and anchoring details.
c) Nameplate legend.
2) Scaled control panel drawings including assembly/layout drawings.
3) Detailed schematic drawings for all control equipment.
4) Panel wiring and piping diagrams.
5) Point-to-point interconnection wiring diagrams.
c. Loop drawings:
1) Submittal of generic diagrams will not be acceptable.
2) Loop diagrams shall show all components of the loop including electrical relays, switches, and other devices necessary for the proper operation of the loop.
3) Loop diagrams shall be organized in a numerical sequence with each loop detailed on a separate drawing.
d. Testing, calibration, and start-up submittal:
1) Detailed testing and start-up procedures. An approved submittal shall be required prior to the commencement of system testing.
a) Training plan submittal.
b) Start-up plan submittal.

D. Variable frequency drives (VFD)s:
    1. Product data:
        a. Manufacturer of the VFD.
        b. Manufacturer of all components of the VFD.
        c. Dimensions:
            1) Height.
            2) Width.
            3) Depth.
            4) Weight.
        d. Nameplate schedule.
        e. Bill of material.
        f. Ratings:
            1) Voltage.
            2) Phase.
            3) Input current.
            4) Output current.
            5) Interrupting rating.
            6) Momentary current rating.
        g. List of recommended spare parts.
        h. Catalog cut sheets for major components.
        i. Design data:
        j. Efficiency and power factor values.
        k. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
        l. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
        m. Certification that all electronic circuits and printed circuit boards are conformally coated.
    2. Shop drawings:
        a. Complete plan and elevation drawings showing:
            1) All dimensions.
            2) Panel, sub-panel and component layout indexed to the bill of material.
            3) Conduit connections.
        b. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
        c. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
            1) Include terminal number and wire numbers.
        d. Complete single-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
            1) Clearly indicate device electrical ratings on the drawings.
    3. Installation instructions:
        a. The written instructions must detail the complete installation of the VFD including moving and setting into place.

b. Provide anchorage instructions and requirements for the VFD based on manufacturer’s recommended practices.

4. Test reports.
5. Manufacturer's field reports:
   a. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
   b. Report listing the setting of all VFD adjustable parameters and their values after start-up.
6. Record Documents:
   a. Certified Record Documents of equipment with information listed above.

E. Motors:
1. Provide submittals as specified in Section 01_33_00.
2. Product data:
   a. Descriptive bulletins for TEFC 3 phase motors 1 horsepower and above, product data must indicate that motors meet or exceed IEEE 841 specifications and that the motor is "premium efficiency," chemical service duty design.
   b. Outline drawings with dimensions.
   c. Cut-away and exploded view drawings.
   d. Parts list with material designations.
   e. Nameplate data.
   f. Motor weight, frame size, and conduit box location.
   g. Description of insulation system.
3. Design and performance data:
   a. Bearing design and bearing life calculations.
   b. Performance Data Required by Schedule A, Nameplate Data, and following Information:
      1) Service factor.
      2) Efficiency at 1/2 and 3/4 load.
      3) Power factor at 1/2 and 3/4 load.
      4) Performance data for motors with synchronous speed of 900 revolutions per minute and below.
      5) Factory test reports with test reference standard identified.

F. Manufacturer's installation instructions:
1. Provide installation and checkout instructions including lubrication and initial start-up procedures.
2. Do not install equipment until all installation instructions have been supplied.

G. The Supplier shall submit a manufacturer’s reference list of at least 5 installations of similar paste-type lime slaker systems at water treatment plants that have been in continuous operation for at least 10 years.
1. List shall include plant capacity, lime storage and feed capacity, installation date, and name, address, and phone number of the contact person.

## 1.06 OPERATION AND MAINTENANCE MANUALS

A. Submittal:
   1. Submit draft and final operation and maintenance manuals in accordance with Section 01_78_24.

B. Product data:
   1. Provide a separate subsection for each major piece of equipment associated with the system. Separate tabs shall be provided in the hard copy of the manual and separate hyperlinks shall be provided in the electronic format. The subsections shall be, but not limited to, the general systems and components listed in Paragraph 1.04.A.2.
   2. Product data shall contain manufacturer's standard literature, illustrations, specifications, and engineering data for all components including total weight of each major component, connection details, and performance data.
      a. Excise or cross out non-applicable information and clearly mark applicable information with citations to and terminology constant with this specification.
      b. Clearly, indicate the model number, materials, and all features selected for each piece of equipment or component.
   3. Approved conformed shop drawings:
      a. Dimensional drawings showing general arrangement of the existing lime slakers, control panels, junction boxes, control panels, etc. at the site.
      b. Scaled control panel drawings including assembly/layout drawings.
      c. Detailed schematic drawings for all control panels and equipment.
      d. Panel wiring and piping diagrams.
      e. Point-to-point interconnection wiring diagrams.
   4. Loop drawings as specified in this Section.
      a. Provide an English language narrative of each control loop including its mission and anticipated action.
   5. List summarizing the factory or field calibrated setpoints for relays, timers, instrument deadbands, and control or alarm contact settings and the adjustable range for each of these settings.

C. Field quality control test results:
   1. After field-testing is completed, insert field test reports and calibration graphs as specified in the equipment section.

## 1.07 QUALITY ASSURANCE

A. Experience requirements:
   1. Slaker equipment supplier:
      a. At least 10 years’ experience in the design and manufacture of slaking equipment similar or identical to the equipment specified in this Section.
      b. A minimum of 5 installations of similar paste slaking of quicklime for 10 years.

B. Materials requirements:
   1. All materials and equipment incorporated into Supplier's equipment shall be of good quality and new.

a. If required by Contractor, Supplier shall furnish satisfactory evidence as to the source, kind and quality of the materials and equipment incorporated into the work.

C. Field service personnel requirements:
1. All field services shall be performed by competent and qualified personnel with at least 5 years of experience in providing field services for similar equipment and providing field services on at least 2 similar installations for Supplier.
a. Submit resume of qualified field personnel for Contractor's review and approval.

D. Welder qualifications:
1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
2. Supplier shall bear costs of retests on defective welds.
3. Supplier shall also bear costs in connection with qualifying welders.

E. Technical and design requirements:
1. Supplier:
a. Maintain a qualified, technical staff and design office.
b. Not be a manufacturer's representative, but the actual manufacturer of the bulk of the equipment specified.
c. Has and shall maintain a competent service organization to service the specified work through project completion and warranty.

F. Contractual requirement:
1. The actual chemical feed systems shall be of Supplier's own design or that of a qualified manufacturer whose relationship will be contractual in nature, and fully sanctioned by the manufacturer for representation and supply on this project.

G. Standard product requirement:
1. Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 5 years prior to bid opening.

## 1.08 WARRANTIES

A. General:
1. No warrantees shall be pro-rated, and all warranties shall include all costs associated with required site visits, inspections, equipment removal costs, and equipment installation costs.
2. All warrantees and support shall be provided directly by Supplier and not the local manufacturer's representative.

B. General equipment warranty:
1. Physical equipment warranty: The equipment furnished under this Section shall be free of defects in materials and workmanship, including damages that may be incurred during shipping, storage, and installation, for a period of 1 year, which shall commence after Notice of Substantial Completion.

## 1.09 DELIVERY, SCHEDULE AND STORAGE

A. Deliver materials to the site to ensure uninterrupted progress of the work. Contractor shall coordinate to deliver products to County approved storage locations. Do not disrupt the treatment plant operations.

B. Supplier shall ensure that all equipment be cleaned externally and internally prior to shipping.
   1. All equipment shall be suitably packaged to facilitate handling and protect against damage during transit and storage.

C. Surfaces shall be protected against impact, abrasion, discoloration, and other damage.
   1. All painted surfaces which are damaged prior to acceptance of equipment shall be repaired to the satisfaction of the Engineer.
   2. Motors, electrical equipment, and controls shall be protected against moisture and water damage during shipment and storage.

D. Supplier shall prepare products for shipment by:
   1. Applying grease and lubricating oil to bearings and similar items.
   2. Separately packing or otherwise suitably protecting bearings.
   3. Tagging or marking products to agree with delivery schedule or shop drawings.
   4. Including complete packing lists and bills of material with each shipment.
   5. Packaging products to facilitate handling and protection against damage during transit, handling and storage.

E. Transport products by methods that avoid product damage.
   1. Deliver products in undamaged condition in manufacturer’s unopened containers or packaging.

F. Supplier shall replace equipment, accessories, and specialties damaged during delivery.

G. Supplier’s local representative, or other supplier designated representative shall be present during unloading of the equipment at the site to observe delivery and to instruct Contractor on recommended long-term storage procedures if applicable.

H. Equipment, including spares will be shipped by the Supplier or the Supplier’s vendor when the equipment is ready and available for shipment.
   1. The Contractor will be responsible for receiving, unloading, and properly storing the equipment in accordance with Supplier’s instructions.
   2. Promptly upon the arrival of any equipment components at the job site or first shipping destination, the Contractor will prepare a receiving report and submit a copy thereof to the Supplier.
   3. The receiving report is to note equipment receipt and all evidence of damage in transit, if any.

## 1.10 DESIGN REQUIREMENTS

A. Electrical:
   1. LS Supplier shall review the Drawings and Specifications, coordinate with contractor and electrical subcontractor, and make all project specific modifications necessary to support supplied equipment and comply with below listed requirements with no additional cost to the County.
   2. Operate electrical equipment successfully at full-rated load, without failure, at an ambient air temperature of at least 60 degrees Celsius, at installation location altitudes.
   3. Coordination of electrical equipment rating:
      a. Verify actual equipment, motor full-load, and locked-rotor current ratings.
      b. When providing equipment with different motor full-load and locked-rotor current ratings than specified, coordinate branch circuit conductor sizes, motor overload protection, motor controllers, control power transformers, and branch circuit overcurrent protection required for equipment provided.
   4. Branch circuit conductor current carrying capacity:
      a. Minimum 125 percent of the full-load current rating of equipment.
   5. Branch circuit conductor size:
      a. Adequate to prevent voltage drop greater than 2 percent from branch circuit protection device to equipment with equipment running at full-load and rated voltage.
      b. Include conductor derating in accordance with ambient temperature and conduit fill requirements.
   6. Motor running overload protection devices:
      a. Nameplate full-load current rating:
         1) 125 percent for motors with marked service factor not less than 1.15.
         2) 125 percent for motors with marked temperature rise not over 40 degrees Celsius.
         3) 115 percent for all other motors.
      b. Size and provide upon verification of actual motor or nameplate data.
      c. Overload heaters required for motors with temperature rise of 50 degrees Celsius:
         1) As selected from motor controller manufacturer's overload heater selection tables.
   7. Motor controller size:
      a. Coordinated with horsepower size of motor. All starters and contactors shall be NEMA rated.
   8. Motor-branch-circuit short circuit and ground fault protections device:
      a. Capable of tripping open in 30 seconds or less on locked-rotor current of motor.
      b. Protect the motor-branch-circuit conductors and the motor control apparatus against overcurrent due to short-circuit or ground faults.
      c. Protect motor control circuits with device type specified.
   9. Panels:
      a. Constructed in a UL certified fabrication shop.
      b. Approved and labeled in accordance with UL 508A requirements.
   10. Electrical design:
      a. In accordance with the NEC.

B. Structural design criteria:
   1. Structures and equipment:
      a. In compliance with codes as specified in Section 01_41_00.
   2. Where conflicting requirements exist, the more stringent shall apply.
   3. Load combinations:
      a. Do not include collateral or auxiliary gravity loads in combinations where dead load offsets the effect of other loads (such as uplift due to wind loads or vertical accelerations due to seismic loads).
   4. Vertical design load:
      a. For the purpose of determining stress, all vertical design loads shall be considered acting alone or in combination with these lateral forces.
      b. The maximum allowable stresses in any structural steel member shall not exceed those permitted by AISC 360.

C. Process:
   1. Lime feed system design (including existing conditions):

| **Lime Slaking System Design Criteria** | |
|---|---|
| Slaker Maximum Capacity, lb/hr<br>(existing and proposed units, each) | 2,000 |
| Quicklime (Pebble) Feed Rate, lb/hr | 2,000 |
| Slaker Maximum Output Lime Slurry Concentration, % | 18% |
| Slaker Minimum Operating Supply Water Pressure, psi | 40 |
| Slaker Maximum Operating Supply Water Pressure, psi | 75 |
| Slaker Water Requirements, gpm (at max. water pressure) | 28 |

   2. Slakers
      a. System feed requirements: The system feed requirements represent the total amount of lime slurry required when summarizing all feed locations:
         1) Chemical: Dry pebble quicklime, delivered by bulk pneumatic trucks with a minimum available calcium oxide of 93 percent. Lime density of approximately 60 pounds per cubic foot (pcf).
         2) Operating hours: 24 hours per day.
      b. Slaking temperature:
         1) The slakers process the specified quantity of quicklime and operate at a final slaking temperature between 170 and 190 degrees Fahrenheit.
      c. The new lime slaking systems shall be installed in the existing area of the Chemical Building, with the new control panels to be located in an adjacent room referred to as the Chlorine Storage Room. Refer to the drawings for additional information.
   3. Utilities:
      a. The following services shall be made available to the lime system, unless shown otherwise on the Drawings:
         1) Electrical power:
            a) 480 volts, 3 phase, 60 Hertz.
            b) Provide step down transformers for low voltage equipment
         2) Utility water:
            a) As indicated on the Drawings, with pressure and flow as specified.

4. All equipment shall be designed for continuous, 24 hours per day, 7 days per week operation, continuous and intermittent operation.
5. All wetted materials used in the production of potable water, or in contact with the water or chemicals used to treat water, shall comply with NSF 60/61 or other acceptable standards per F.A.C. 62-555.

## 1.11 COORDINATION

A. An instrumentation and control system contractor (ICSC) shall be responsible for integrating the control systems specified in this Section with existing systems and other plant process control, instrumentation, and electrical improvements. The new slaker control panels shall be installed inside the Chemical Building Chlorine Storage Room , such that it provides control of the slakers, and interfaces similarly to the existing SCADA system.

B. The LSS Supplier shall assist in this integration effort and shall provide all information, testing, start-up, documentation, and training services required by the ISCS to fully integrate the control systems specified in this Section.

## 1.12 PERFORMANCE GUARANTEES

A. Slaker and feeders deliver the rated capacities specified herein.

B. Entire system:
1. Conforms to the design requirements specified in this Section.
2. Performs its intended functions and will operate in a satisfactory manner as specified in this Section.
3. Meets all OSHA safety guidelines and requirements.

C. Provide evidence that equipment warranty can be met.

D. Supplier demonstrates that the specified spare parts are available for shipment to the project site within 24 hours.

## 1.13 MAINTENANCE

A. Provide 1 set of special tools needed to assemble/disassemble the system.
1. Properly packed and protected for long-term storage and placed in containers clearly identified in indelible markings to contents.

## 1.14 SPARE PARTS

A. Properly packed and protected for long-term storage and placed in containers clearly identified in indelible markings to contents.

B. Manufacturer shall furnish a complete list of all parts, and provide all parts for warranty period.

C. Provide the following spare parts as minimum:
1. All gaskets, seals, packing, etc.: 2 extra sets.
2. V-belt drives for all belt driven equipment: 2 spare.
3. Pilot lights: 3 per panel.

D. Slakers
    1. Furnished with the manufacturer's recommended spare parts to include as a minimum, the following:
        a. One (1) feeder flanged bearing.
        b. One (1) feeder spout inspection gasket.
        c. One (1) feeder spout gasket.
        d. Two (2) slaker drive V-belts, if required.
        e. Two (2) sets of slaker torque valve diaphragms or valve seats, if required.
        f. Two (2) rebuild kits for mechanically actuated water valves.
        g. Ten (10) left and right hand slaker paddles.
        h. Two (2) slaker shaft seals.
        i. Two (2) slaker solenoid valves for each size provided.
        j. Four (4) slaker cut-off spray heads.
        k. Two (2) slaker dust arrestor spray heads.
        l. Five (5) each, spare indicator bulbs, fuses, and control relays of each type for each control panel provided.
        m. One (1) complete set of gaskets, O-rings, and lubricant tubes for each slaker system supplied.

E. Provide the following spares for each control panel:
    1. Furnish 1 spare normally open and 1 spare normally closed dry contact for each pushbutton, selector switch, relay, etc.
    2. Furnish 15 spare terminal blocks or 20 percent whichever is greater.
    3. Fuses for each and every fuse in the panel: 5 spares.
    4. All spare contacts of relays, switches, etc., shall be internally wired to terminal blocks.

F. All spare contacts of relays, switches, etc., shall be internally wired to terminal blocks/VFDs:
    1. The following spare parts shall be furnished:
        a. 1 set of all power and control fuses for each VFD.
        b. Any special dedicated tools for emergency service and troubleshooting.
    2. All hardware and software required for configuration, maintenance, troubleshooting, and inquiry of all drive parameters.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

A. Lime Slaker Suppliers, including slaker control panel and appurtenances., the following or equal:
    1. Integrity Municipal Systems (IMS).

### 2.02 IDENTIFICATION

A. Nameplate:
    1. Identify each unit of equipment with a corrosion resistant nameplate, securely affixed in a conspicuous place.
    2. Nameplate information to include equipment model number, serial number, manufacturer's name, and location.

3. Provide black lamicoid nameplates with white letters for all panel devices.
4. Nameplates shall be fastened to the control panel with epoxy adhesive.
5. Provide each component with Type 316 stainless steel nameplates indicating critical information for each component.
6. Provide each control panel with white on black phenolic nameplates describing function of each control panel mounted component, whether front-mounted on the panel door or interior-mounted.
7. Provide each control panel with a permanently mounted Type 316 stainless steel or plastic nameplate indicating the following:
    a. Panel name.
    b. Supplier.
    c. Manufacturer.
    d. Year fabricated.

## 2.03 GENERAL

A. Scope:
1. This Section is intended to give a general description of what is required, but do not cover all details which may vary in accordance with the exact requirements of the equipment as offered.
    a. They are, however, intended to cover the furnishing, delivery, installation, and field-testing of all material, equipment, and apparatus as required.
    b. Any additional auxiliary equipment necessary for proper operation of the proposed installation not mentioned in this Section shall be furnished and installed by Contractor, excluding external connections required for system utilities.
2. The material covered by this Section is intended to be standard equipment of proven ability and as manufactured by reputable companies having experience in the production of such equipment.
    a. The equipment furnished shall be designed, constructed, and installed in accordance with the best practice and methods and will operate satisfactorily when installed as stated in this Section.

B. Design:
1. All equipment shall be designed and fabricated to have liberal strength, stability, and stiffness and to be especially adapted for the intended service.
2. Chemical handling and feed equipment shall be of substantial construction with all parts designed for long life under the prevailing working conditions.
3. All wearing parts and items requiring adjustment and cleaning shall be readily accessible.
4. All equipment and piping shall be rigidly and accurately anchored into position and all necessary foundation bolts, plates, nuts, and washers shall be furnished and installed.
    a. Anchor bolts furnished and installed by Contractor.
5. All bolts, nuts, washers, clamps, etc., used to interconnect components shall be furnished by Contractor.

C. Safety:
1. Electrical materials and equipment:
    a. UL listed.
2. Removable, all-metal guards:

a. In accordance with OSHA.
b. Provide for all motor couplings, V-belt drives, and similar exposed rotating elements.

D. Dust environment:
1. Each system, when completed, shall be completely dust-tight when in operation.
2. NEMA Type 4X rated devices:
a. All, junction boxes, and terminal boxes unless otherwise indicated or specified.
b. Type 316 stainless steel control panels unless otherwise indicated or specified.

E. Other environments:
1. Equipment installed outdoors will be weathertight, suitable for outdoor operation.
2. All parts which are exposed to corrosive conditions shall be made from corrosion resistant materials or covered with suitable protective coatings.
3. The slaker control panels slated for installation within the chlorine tank storage room must possess corrosion-resistant properties and effectively prevent the infiltration of chlorine gas into the panels.

## 2.04 MATERIALS

A. All materials provided for the lime storage and feed equipment and accessories shall be designed for complete compatibility with bulk quicklime and quick lime slurries.

B. All materials in contact with lime or lime slurry utility water shall conform to NSF 61, or other applicable standards per F.A.C. 62-555.

## 2.05 EQUIPMENT

A. Lime feeding systems:
1. Shut-off rotary valve:
a. Provide a rotary valve with lever operator to connect directly to the silo discharge. Match existing bolt pattern or provide adaptor flange.
b. Provide inlet flexible connector as necessary for alignment.
2. Lime feeder:
a. The slaking system will include a screw type volumetric feeder to control the feed rate of pebble lime into the slaker.
b. In order to facilitate on-site assembly of the slaking system and assure proper fit and function of all system components the feeder shall be supplied by the same manufacturer as the slaker.
c. Each unit shall be screw-type volumetric feeder having a capacity of 33 cubic feet per hour or 2,000 pounds per hour of pebble lime, and complete with a 2.5” lime feed screw; VFD speed control with 1 horsepower 480 volt, 3 phase, 60Hz, TEFC AC motor; and right-angle drive gearbox. The feeder shall be constructed of 316 stainless steel.

d. A VFD shall be provided, factory mounted and wired to current NEC requirements, within the system control panel. Power supply to the VFD will be 480VAC, 3 phase, 60Hz from the slaker control panel.
e. Provide access panel for feeder inspection and maintenance.

B. Lime Slakers:
1. The proposed lime slaking systems shall be installed within the existing area of the Chemical Building. The proposed relay-based control panels shall be installed in an adjacent room within the Chemical Building referred to as the Chlorine Storage Room. The slaker converts the dry pebble quicklime fed by the lime feeder into lime slurry, which shall be discharged into an existing slurry tank before being pumped to the process as required by the site operating conditions. The slaker system shall include a grit remover to separate the grit from the slaked lime.
a. Slakers shall each consist of a slaking compartment containing two sets of counter-rotating, intermeshing paddles, a minimum of five paste cut–off sprays, a dilution chamber, a dust and vapor remover, a mechanical torque operated water modulating inlet valve and a low water pressure switch. The drive mechanisms and rotating equipment shall meet OSHA requirements. The slakers shall be of all welded construction, fabricated of heavy gauge steel plate and structural shapes.
b. Paste consistency controlled by mechanical torque operated valve.
c. At the end of the slaking compartment, the paste shall be discharged over a weir into a dilution chamber where a continuous water spray shall cause it to become a slurry.
2. Wetted Materials Construction: 316 stainless steel.
3. Capacity: 2,000 pounds per hour.
4. Slaking Ratio: 2:1 water to lime by weight, automatically controlled.
5. Slaker operating range: 20:1 turndown.
6. Process water temperature range: 7-30 degrees Celsius.
7. System feed and operating requirements and slaking temperature: Refer to Section 1.09.
8. Operation:
a. An increase in motor load (torque) on the mixing paddles shall cause a mechanically controlled water control valve to admit additional water and thereby control paste consistency automatically. Grit shall be carried through the slaking compartment by the paste to the conveyor grit separator mechanism.
b. A selector switch shall allow operation in a batching mode (for overnight shutdown) or in a complete shutdown mode. For batching, the lime feeder shall stop but the jet spray in the dilution chamber shall continue for an adjustable time period before stopping. The paddle shafts shall continue to operate during system shutdown for an adjustable time period not less than 15 minutes. For complete system shutdown, the feeder shall stop, the paddle shafts shall continue to operate for an adjustable time period not less than 15 minutes to slake the remaining pebble lime and then water shall flood the slaking compartment to dilute the remaining paste, and the entire system shall stop after a set time. After initiation of the shutdown sequence, the lime slaking system shall automatically flush the slaking and dilution compartments of all lime paste and slurry, and discharge the residue into the existing lime slurry tank.

9. System Components:
    a. Supply Water Panel:
        1) Provide pre-assembled water panel.
        2) Panel shall be sized by the slaker manufacturer.
        3) Provide copper piping and valves, complete with strainer, pressure reducing valves, pressure gauges and switches, flow meters, solenoid valves with bypass, and;
    b. Grit Remover:
        1) The grit remover shall be a flight-scraper conveyor-type grit remover with the ability to remove separate grit by specific gravity, removing virtually all grit down to 10 mesh in size and a portion of finer grit down to 40 mesh.
        2) 316 stainless steel construction.
        3) ¼ HP 480V, TEFC gear motor.
        4) Scrapers shall be replaceable.
        5) Supply water control valve for grit washwater flow.
    c. Control Panels as specified in this section and comply with requirements in Division 40.
        1) Prewired Slaker Control Panels shall be supplied by the slaker manufacturer.
        2) NEMA 4X, Type 316 stainless steel and remotely mounted as indicated on the Drawings.
        3) The panel controls shall be relay-based with local operator hand switches and pilot lights.
10. Requirements:
    a. Entire slaking system shall be pre-assembled, piped, wired, and factory tested prior to shipment.
    b. Design and provide 316 stainless steel work platform for access to internal paddles and components of the slaker, with respect to the existing dimensions of the silos.
    c. Provide vapor and dust vent in accordance with manufacturer's requirements.
    d. Provide overflow connection routed to drain.

C. Lime slurry (LMS) piping:
    1. Provide lime slurry piping from the new slakers to slurry tanks. Refer to drawings for PVC sizing.
        a. Piping from slaker to tanks shall be flexible Sch 80 PVC piping.
    2. Provide quick couplings near the lime slurry tank and connections, and for each PVC segment. Do not exceed runs of 20 foot segments.

## 2.06 CONTROL PANELS

A. General:
    1. Control Panel shall accept 480V, 3 phase power and shall be equipped with integral safety disconnect switch.
    2. Control panels shall be manufactured and assembled in a UL registered shop:
        a. All components (relays, breakers, pilot devices, etc.), wiring and labeling shall be the manufacturer's standard to meet UL requirements:
            1) Prior to shipment, all control panels shall be inspected, approved, and labeled in accordance with UL 508A requirements.

2) Control panels shall be furnished by Supplier and installed by the Contractor.

3. The control panel shall house all of the designated electrical equipment including motor starters.

B. Slaker Control Panels:
1. The slaker electrical control panel shall provide electrical control for the respective slaker, feeder, grit remover and screw feeder vibrator.
2. The control panel enclosure shall be rated NEMA 4X 316SS powder coated in white. The panel shall be remote-mounted in an adjacent room within the Chemical Building referred to as the Chlorine Storage Room by the contractor.
3. A junction box shall be provided mounted on the slaker and be factory pre-wired to system components.
4. The panel shall be based on relay logic control and shall have as a minimum the following components or functionality:
   a. Hand/Off/Auto selector switch for the screw feeder vibrator.
   b. Pebble lime feed-rate control.
   c. Pebble lime feed rate display.
   d. Manual and automatic operation of the lime feeder.
   e. Running/Fault indication of the lime feeder status.
   f. Manual and automatic operation of the paddle-shaft mixer motor.
   g. Running/Fault indication of the paddle-shaft mixer motor status.
   h. Manual and automatic operation of the grit remover.
   i. Running/Fault indication of the grit remover status.
   j. Alarm Indication for the following:
      1) Slaker paddle shaft mixer fault.
      2) Lime feeder fault.
      3) Grit remover fault.
      4) Control Power off.
      5) Inlet water low pressure.
      6) Emergency stop active.
5. Contractor shall provide source of power (480v, 3 Ph, 60Hz) for the control panel. Provide the control and power transformers as necessary to step down the feed voltage from 480 volts, 3 phase, 60 Hertz to the required control voltage.
6. Motor Starter assemblies and VFDs including motor circuit protector (MCP) with adjustable instantaneous trip setting, and motor started contractor and thermal overload assemblies as indicated for:
   a. Screw Feeder.
   b. Lime Paste Slaker.
   c. Grit Remover.
   d. Screw Feeder Vibrator.
7. Control panel shall be provided with terminal strip for easy wiring connections for inputs and outputs.
8. The panel shall provide for the following types of operation and control:
   a. Manual speed control of the feeder via a potentiometer.
   b. Automatic control of feeder rate via a 4-20 mA input signal from the plant control system based on flow or process conditions.
   c. Automatic batching.
   d. Automatic system shutdown.
   e. Programmable flush cycle after each shutdown.

C. The following I/O shall be provided for status, monitoring and control to the plant control system (Slaker systems No.1 and No.2 only):
    1. Inputs:
        a. Remote Shutdown dry contact from Plant control system.
        b. Feeder Rate Set Point in 4-20mA signal from Plant control system.
    2. Outputs:
        a. Slaker System IN REMOTE status dry contact to Plant control system.
        b. Slaker System RUNNING status dry contact to Plant control system.
        c. Slaker System FAIL status dry contact to Plant control system.

D. All motors shall meet the requirements as specified in Section 26_20_00 unless otherwise indicated in this Section.

E. All disconnect switches required in this Section shall meet the following requirements:
    1. Disconnect switches shall be located within line of sight, where possible.
    2. Disconnect switches shall be heavy duty, horsepower rated for all motor loads.
    3. Disconnect switches with knockout shall not be acceptable.
    4. When required due to available short circuit current, disconnects shall be fusible or circuit breaker type to meet required available short circuit ratings.
    5. When load is fed from a VFD, provide auxiliary make before break contacts to interlock with the drive to prevent disconnecting power under load.
    6. Rotary handle disconnect switches shall not be acceptable.
    7. Disconnects shall be lockable in the OFF position.

F. Variable frequency drives (VFD):
    1. Manufacturers:
        a. VFDs: One of the following or equal:
            1) Danfoss.
            2) Eaton/Cutler Hammer.
            3) Allen-Bradley.
            4) Siemens-Robicon.
            5) Schneider Electric/Square D.
            6) General Electric.
            7) ABB.
    2. Sinusoidal pulse width modulated (PWM) type drive.
        a. 6-pulse insulated gate bipolar transistor (IGBT) power section.
        b. Microprocessor based controls.
    3. Input voltage: 480 volts within 10 percent, 3 phase, 60 hertz.
    4. Operation in either a constant volts/hertz or sensorless vector mode.
    5. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
    6. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:
        a. Provide equipment necessary to mitigate potential damage to motor insulation.
    7. Performance:
        a. Operating envelope:

1) Speed and torque requirements:
    a) Provide a variable torque or constant torque VFD as required by the driven load.
    b) VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 hertz) speed range.
2) Current requirements:
    a) 100 percent of rated current output on a continuous basis.
    b) Variable torque VFD:
    c) Minimum 110 percent current overload for 1 minute.
    d) Constant torque VFD:
    e) Minimum 150 percent current overload for 1 minute.

b. Minimum VFD system efficiency:
    1) 96 percent.
    2) VFD system efficiency shall be calculated as follows:

$$\text{Efficiency} \quad (\%) = \frac{\text{Power} \quad (\text{Load})}{\text{Power} \quad (\text{Supply})} \text{ x } 100$$

        a) Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters, or transformers. Power (Supply) is the total power measured at the input terminals of the VFD including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.

c. Total power factor:
d. Minimum of 0.96 lagging across the entire speed range.
    1) At no speed shall the VFD have a leading power factor.
e. Frequency accuracy:
    1) Minimum of within 0.01 percent.
f. Speed regulation:
    1) Minimum of within 0.5 percent across the entire speed range.

8. Frequency control:
    a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
    b. Programmable minimum frequency.
    c. Programmable maximum frequency.
9. Enclosure as required for the environment.
    a. Where located outdoors, enclosure shall be NEMA 4X.
10. Provide cooling as necessary to maintain temperature rating of the VFD.
11. 3 percent input and reactors.
12. Provide each VFD with a keypad mounted on the VFD for programming and control.
13. Conformal coating:
    a. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H2S and chlorine.
14. Inputs/Outputs:
    a. Manufacturer's standard number the following:
        1) Analog inputs:
            a) Configurable as 4-20 mA.

2) Analog outputs:
a) Programmable 4-20 mA isolated.
3) Discrete inputs:
a) Programmable.
4) Discrete outputs:
a) Programmable.
b) Form C relay contacts.
5) Potentiometer 3-wire input.

15. Qualifications:
a. Any third party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
b. VFD systems shall be UL 508C listed and labeled.
1) Variable frequency drives shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program that is certified in conformance with ISO 9001.

G. All transformers, protection, and power supplies needed to convert the supply voltage to the needed utilization voltage within each control panel:
1. Control power transformer shall be sized so that the maximum inrush current does not cause the secondary voltage of the transformer to fall below 85 percent of rated voltage when the primary voltage has been reduced to 90 percent of rated voltage.

H. Combination starters, NEMA rated minimum Size 1, with main circuit breaker, magnetic starter, control transformer, and other controls as required.

I. Circuit breaker protection for other individual loads, including motor heaters.

J. Terminal blocks for termination for field wiring. All termination blocks and wiring shall be labeled. Wires shall be labeled with preprinted sleeve labels:
1. All electric signals shall be electrically or optically isolated from other signals.
2. Discrete input signal shall be 120 VAC, unless otherwise noted.
3. Discrete output signals shall be:
a. 120 VAC dry contact or triac output as needed to coordinate with the field device, unless otherwise noted.
b. Discrete outputs from the control panels shall be provided by electrically isolated contacts rated for 10 amps at 120 VAC through the use of interposing relays.
c. All discrete outputs without exception shall be routed through an external terminal block mounted fuse with blown fuse indication:
1) Size external fuse to open before any I/O card mounted fuses.

K. Wiring:
1. Internal power and control wiring shall be 600 volt rated THWN-2, MTW, or THHN:
a. Install minimum Number 12 American Wire Gauge wiring for power circuits, and minimum Number 14 American Wire Gauge for control wiring.

f. Size power conductors in accordance with NEC when sizes are not specified.

9. All wires shall be run in plastic wireways, except as follows:
    a. Field wiring.
    b. Wiring run between mating blocks in adjacent sections.
    c. Wiring run from components on a swing-out panel to components on a part of the fixed structure.
    d. Wiring run from components on a swing-out or front panel to other components on a fixed panel shall be made up in tied bundles.
    e. These bundles shall be tied with nylon wire ties, and shall be secured to panels at both sides of the “hinge loop” so that conductors are not strained at the terminals.
    f. Wiring run to front panel-mounted components.
10. Materials:
    a. Conductors:
        1) ASTM B 8, soft drawn copper, maximum 12 months old, minimum 97 percent conductivity.
        2) American Wire Gauge sizes as specified, Class B or C stranded.
    b. Insulation thickness: Minimum specified by NEC Article 310.
    c. Low voltage wiring shall be run separately from power and 120 VAC control wiring.
    d. 120 VAC circuits shall be run through grey colored plastic wireways.
    e. 24 VDC circuits shall be run through white colored plastic wireways.
    f. Provide an empty wireway for all field wiring connections.

L. For case grounding, panels shall be furnished with a 1/4-inch by 1-inch copper ground bus complete with solderless connectors for all equipment ground conductors.

M. All field conduit connections shall be bottom-entry.

N. Internal control components shall be mounted on an internal back-panel.

O. Devices may be mounted on the side-panel if shown on the drawings or only by special permission from the Engineer.

P. All control panel mounted operator interface devices shall be mounted between:
1. A minimum of 3 feet above finished floor elevation.
2. A maximum of 6 feet above finished floor elevation.

Q. Control panel components:
1. 120 VAC circuit breakers:
    a. Manufacturers: The following or equal:
        1) Schneider Electric/Square D QOU Series, thermal magnetic.
2. Magnetic motor starters:
    a. Manufacturer: Eaton/Cutler-Hammer or equal.
    b. Suitable for the horsepower ratings specified, and in accordance with NEC Article 430.
        1) Provide starters of sufficient size to accommodate motors furnished.
    c. Verify motor ratings and coordinate starter and overload trip ratings with actual horsepower and nameplate current ratings of motors installed.

d. Magnetic contactors: Factory adjusted and chatter free.
e. Overload relays: Install bimetallic type or solid state type overload relays in each line conductor. Provide contacts for remote monitoring of overload status.
f. Provide starters Size 2 and larger with arc quenchers on load breaking contacts.
g. Minimum size starter: NEMA Size 1.
h. Provide 3 overload relays with plus or minus 15 percent adjustment from nominal heater rating on the overload relay; cover mounted reset button, and at least 3 reversible contacts in addition to hold-in contact.
i. Supply circuit breaker trip elements and starter overload trip elements to meet specified environmental conditions.

3. Non-fused terminal blocks: Sized as required for conductors:
   a. Manufacturers: One of the following or equal:
      1) Schneider Electric/Square D.
      2) Buchanan.
4. Fused terminal blocks: Circuit isolation, fused switch type, sized as required for conductors. Fuse size shall be based upon actual load and conductors to be protected.
   a. Manufacturers: One of the following or equal:
      1) Schneider Electric/Square D.
      2) Buchanan.
5. Control relays:
   a. Industrial 600-volt, 10-ampere type with contact arrangement and operating coils of proper voltage as required by control circuit sequence; with minimum of 4 reversible-pole contacts; coils sealed by pressure molding.
   b. Non-industrial type control relays shall be prohibited unless accepted in writing.
   c. Manufacturers: One of the following or equal:
      1) Schneider Electric/Square D.
      2) Eaton/Cutler-Hammer.
6. Timing relays: Heavy-duty industrial, 600 volts, 10 amperes.
   g. Manufacturers: One of the following or equal:
      1) Schneider Electric/Square D.
      2) Eaton/Cutler-Hammer.
7. Environmental:
   a. Heating devices shall be provided in the control panels order to prevent formation of condensation within the control panel.
8. Pilot devices:
   a. Oiltight/watertight pushbuttons, selector switches, and pilot lights.
   b. All project pilot devices shall be rated NEMA Type 4X.
   c. Individual pilot lights shall be push-to-test, transformer-type LED.
   d. Provide indicating light colors as follows:
      1) Power on: White.
      2) On or running: Green.
      3) Off: Red.
      4) Status or normal condition: White.
      5) Abnormal or alarm condition: Red.
      6) Failure: Red.
      7) Open: Amber.

8) Closed: Blue.
e. Provide pushbutton color code as follows:
1) Red: Stop.
2) Green: Start.
3) Orange: Open.
4) Blue: Close.
f. Manufacturers: One of the following or equal:
1) General Electric, CR104P. (22.5 millimeter).
2) Allen-Bradley, Bulletin 800H. (22.5 millimeter).
9. Digital panel indicators:
a. Red Lion, Model PAXP.
10. Terminal blocks:
a. Products:
1) Standard type: Phoenix Contact.
2) Disconnect type: Phoenix Contact.
3) Terminal end cover: Phoenix Contact.
4) Fused indicating type (120 volts): Phoenix Contact.
5) Fused indicating type (24 VDC): Phoenix Contact.
6) Cover: Phoenix Contact.
7) Grounding: Phoenix Contact.
8) Grounding end cover: Phoenix Contact.
9) End clamps: Phoenix Contact.
b. Terminal block labeling: Each terminal and each conductor as previously specified with machine labels only.
c. Each source of foreign voltage entering a control panel shall be isolated by providing disconnecting terminal blocks.
d. All field/remote connections shall be made via terminal blocks.
e. Furnish an individual terminal block space for each wire. 2 wires on 1 terminal block shall be not be allowed.

R. Identify 3 phase system conductors and cables as Phases A, B, and C and identify 1 phase system conductors and cables at each control panel:
1. 3-phase, 480 VAC Conductors: Phase A, brown; Phase B, orange; Phase C, yellow.
2. Single-phase conductors for 120/240 VAC circuits: Phase A, black; Phase B, red.
3. Neutral conductor: White for 120 VAC.
4. Insulated equipment grounding conductor: Green.
5. General purpose alternating current control conductors: Red.
6. General purpose direct current control conductors: Blue.
7. Externally fed control circuits (interlocks): Yellow.
8. PLC discrete I/O: Violet.
9. 24 VDC positive: Blue.
10. 24 VDC negative: Gray.

S. Nameplates
1. Provide black lamicoid nameplates with white letter for all panel devices.
2. Nameplates shall be fastened to the control panel with epoxy adhesive.

T. Relays
1. Control:

a. Standard type: IDEC Model RH4BULAC120V.
2. PLC discrete output interposing:
a. Phoenix Contact: PLC-RSC-120UC/21HC.
3. Time delay:
a. Delay on make: IDEC RTE-P11-AC120V.
b. Delay on break: IDEC RTE-P21-AC120V.
4. Provide transient surge protectors across the coil of each relay.

U. Direct current power supplies:
1. Manufacturers: One of the following or equal:
a. Phoenix Contact, Quint Series.
b. IDEC, PS5R Series.
2. Direct current power supply units shall be switching type.
a. Line regulation shall not exceed plus or minus 0.4 percent for 95 to 132 VAC input variation.
b. Load regulation shall not exceed plus or minus 0.2 percent for 0 to 100 percent load variation.
c. Ripple shall not exceed 150 millivolts peak to peak.
d. Temperature coefficient shall not exceed 0.03 percent per degree Celsius.
3. Automatic adjustable overvoltage shutdown and overtemperature protection shall be included.
a. An integral or external undervoltage relay shall provide an alarm on undervoltage, overvoltage, or overtemperature.
b. Transient voltage response to a 50 percent step change in load shall not exceed 0.25 volts or plus or minus 0.1 percent after 20 milliseconds.
c. Hold-up time shall be 16.7 milliseconds or greater.
d. Efficiency shall be 75 percent or greater.
e. Conducted electromagnetic interference (EMI) shall conform to FCC Docket 20780, Class A. Radiated EMI shall be minimized with suitably designed screened enclosures.
4. 24-volt nominal power supply systems shall be of redundant configuration and shall provide 26.4 volts at the distribution terminals at no load.
a. An allowance for voltage drop across redundant unit isolation diodes will typically necessitate the selection of 28 volt nominal power supply units with outputs adjusted to suit.
b. The capacity of each unit shall be 50 percent greater than the maximum system connected load.
5. An alarm contact from each direct current power supply shall be connected to the PLC and alarmed on the SCADA system.

V. 120 VAC service receptacle:
1. Duplex, GFI rated, DIN rail mounted, 125 volts, 20 amperes.
2. Manufacturers: The following or equal:
a. Phoenix Contact EM-DUO 120/20/GFI.

W. Category 6 cable:
1. Material:
a. Used for final connections to fiber-optic media converters and PLCs.
b. CMP/MPP rated, with FEP - fluorinated ethylene propylene (Teflon) insulation.

c. Four pair, solid bare copper 24 American Wire Gauge, Category 6, UTP, as defined by the EIA/TIA standards intended for use with transmission rates up to and including 100 megabytes per second.
d. Manufacturer: The following or equal:
   1) Belden.

## 2.07 AUTOMATIC EQUIPMENT WARNING AND HIGH VOLTAGE SIGNS

A. Mount permanent warning signs at mechanical equipment which may be started automatically or from remote locations.
   1. Fasten warning signs with round head stainless steel screws or bolts, located and mounted in a manner acceptable to Engineer.

B. Place warning signs on utilization equipment that has more than 1 source of power.
   1. Provide panel and circuit number of conductor tag of the power source disconnect.

C. Place warning signs on utilization equipment that has 120 VAC control voltage source used for interlocking.

## 2.08 COATINGS

A. All coatings shall conform to the requirements of Section 09_96_01.

B. Immersed ferrous metal: High Solids Epoxy System as specified in Section 09_96_01.

C. All other ferrous metal, unless specified otherwise, including lime silo exterior, skirt enclosure, and other equipment: High Solids Epoxy and Polyurethane System as specified in Section 09_96_01.

D. Stainless steel and aluminum equipment shall not be painted, except for the lime slaking system. The lime feeder, slaker, grit remover, and local system control panel shall all be 316SS and be painted with 2-part marine grade epoxy conforming to NSF 61 or other acceptable standards per F.A.C 62-555.

E. All prime painting shall be done in the shop prior to shipping.

F. All machined metal surfaces will be coated with a suitable, easily removable rust inhibitive compound prior to shipment.
   1. Upon receipt of any materials coated with a rust inhibitive compound, the Contractor shall insure that the coating is intact prior to storage and maintain the coating until installation of the equipment.

## PART 3 EXECUTION

### 3.01 FIELD QUALITY CONTROL

### 3.02 FIELD PAINTING

A. Supplier shall be responsible for furnishing touch-up paint as required by Contractor to complete the installation of Supplier furnished equipment specified.

B. Contractor shall be responsible for applying touch-up paint on Contractor-furnished equipment in accordance with the manufacturer's instructions.

C. Contractor shall be responsible for labeling of all piping provided by Supplier with arrows indicating direction of flow and letters indicating service (i.e. "dry lime," "lime slurry").

### 3.03 INSTALLATION

A. Contractor shall inform County of proposed schedule at least 14 days prior to beginning work on the slaker system. Contractor shall coordinate with County and Engineer to ensure that the plant equipment is operational and that the equipment can be taken out of service.

B. Contractor shall be responsible for the field installation, testing, and placement into operation of any items shipped loose provided by Supplier.

C. Lime systems shall be installed under the direction of the system supplier in strict conformance with the manufacturer's installation instructions and with favorable review shop drawings.

D. Check out of final installation, start-up, calibration, and instruction of operating personnel shall be performed by an authorized representative of the manufacturer. Supplier's service manual shall provide any special procedures for installation.

E. Upon acceptance by the Engineer, alignment of piping may vary from that indicated on the Drawings to suit the equipment furnished, without additional cost to County.

F. Set all anchor bolts in accordance with the drawings and instructions of Supplier and/or equipment manufacturers.

G. See Section 03_60_00 for grouting under baseplates and additional installation specifications.

H. Disinfect from the rotary valve through the lime slaker assembly, and through the slaker discharge pipe to the slurry tank, per Section 01_75_18.

### 3.04 MANUFACTURER'S FIELD SERVICES

A. Supplier shall provide the services of a factory field service representative as follows, with the number of trips and service days required to comply with all specified requirements:
   1. Observe/advise Contractor on the construction of the lime system.

2. Assist in start-up and commissioning of system.
3. Assist in functional and operational testing of system.
4. Furnish test forms, testing equipment, and procedures for field-testing.
5. Train County's personnel on the operation and maintenance of the equipment.

B. Prior to initial start-up, a written statement shall be provided by Supplier to Contractor stating the equipment has been installed by Contractor accordance with the manufacturer's requirements and is ready to be placed into operation.

C. The representative shall operate and test system in the presence of Contractor and verify that the equipment conforms to the specified requirements, and instruct plant personnel on care and maintenance.

D. The representative shall revisit the job site as often as necessary until all deficiencies are corrected and the installation and operation is satisfactory to County.

E. Manufacturer's installation report:
1. Prepare manufacturer's installation reports and submit within 30 days after completion of field-testing. The reports shall include the following:
a. Project name and number.
b. Field-testing reports.
c. Description of installation deficiencies.

## 3.05 START-UP AND TESTING PROCEDURES

A. In general, Contractor shall perform the following functions prior to start-up and testing of the equipment under direct supervision of Supplier's field representative:
1. Remove rust preventatives and oils applied to protect equipment during construction.
2. Install and adjust packing, mechanical seals, O-rings, and other seals. Replace defective seals.
3. Remove temporary supports, bracing, or other foreign objects installed to prevent damage during shipment, storage, and erection.
4. Check rotating machinery for correct direction of rotation and for freedom of moving parts before connecting driver.
5. Perform cold alignment and hot alignment to manufacturer's tolerances.
6. Adjust V-belt tension and variable pitch sheaves.
7. Inspect hand and motorized valves for proper adjustment.
a. Tighten packing glands to insure no leakage, but permit valve stems to rotate without galling.
8. Verify valve seats are positioned for proper flow direction.
9. Tighten leaking flanges or replace flange gasket.
a. Inspect screwed joints for leakage.
10. Install gratings, safety chains, handrails, shaft guards, and sidewalks prior to operational testing.
11. Submit Manufacturer Field Representative's certification of installation.
12. Instrumentation systems:
a. Bench or field calibrate instruments and make required adjustments and control point settings.
b. Leak test pneumatic controls and instrument air piping.

c. Energize transmitting and control signal systems, verify proper operation, ranges, and settings.

B. Supplied Equipment:
   1. Contractor, under the supervision of Supplier, shall perform or demonstrate the following general requirements:
      a. Perform checkout and performance testing as specified in the individual equipment sections.
      b. Perform a functionality test of mechanical and electrical equipment, and instrumentation and controls systems for proper operation after general start-up and testing tasks have been completed.
      c. Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration.
      d. Perform initial checks in the presence of and with the assistance of the manufacturer's representative.
      e. Demonstrate proper operation of each instrument loop function including alarms, local and remote controls, instrumentation and other equipment functions.
      f. Generate signals with test equipment to simulate operating conditions in each control mode.

C. Failure testing:
   1. In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
      a. Equipment failure.
      b. Operator error.
      c. Communications sub-system error.
      d. Power failure.
      e. Process equipment failure.
      f. High system loading conditions.

D. Loop check/validation:
   1. Check all control loops under simulated operating conditions.
   2. Provide "end-to-end" tests:
      a. Test SCADA system inputs and outputs from field device to SCADA system operator workstations.
      b. For each signal, perform separate tests for SCADA computer screens, and local control panels.

E. Functional test:
   1. General:
      a. Commence pre-commissioning tests after completion of all loop check/validation tests.
      b. Pre-commissioning to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

2. Control logic operational validation:
    a. The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
3. Pre-commissioning validation sheets:
    a. Document each pre-commissioning test on an approved test form.
4. Pre-commissioning certification:
    a. Document via a certified report the completion of all pre-commissioning and test activities:
        1) Including all test forms with test data entered, submitted to Contractor with a clear and unequivocal statement that all pre-commissioning test requirements have been satisfied.

F. Provide all test apparatus required at no extra cost.

G. Follow testing procedures recommended by the manufacturer and approved by Contractor.

H. Conduct continuous 8-hour test under full load conditions:
1. Replace parts as necessary that operate improperly.

## 3.06 FUNCTIONAL TESTING

A. Contractor, under the supervision of Supplier, shall perform checkout and performance testing as specified in the individual equipment sections.

B. Contractor, under the supervision of Supplier, shall perform a functionality test of mechanical and electrical equipment, and instrumentation and controls systems for proper operation after general start-up and testing tasks have been completed.

C. Contractor, under the supervision of Supplier, shall demonstrate proper rotation, alignment, speed, flow, flow distribution, pressure, vibration, sound level, adjustments, and calibration.
1. Perform initial checks in the presence of and with the assistance of Supplier's representative.

D. Contractor, under the supervision of Supplier, shall demonstrate proper operation of each instrument loop function, including alarms, local and remote controls, instrumentation, and other equipment functions.
1. Generate signals with test equipment to simulate operating conditions in each control mode.

E. Instrument calibration sheets shall be completed for each and every field instrument and/or analyzer that provide the following information and a space for sign-off on individual items and on the completed unit:
1. Project name and number.
2. Loop number.
3. Tag number.
4. Manufacturer.

5. Model number.
6. Serial number.
7. Analog input devices:
    a. Calibration range.
    b. Calibration data: Input, output, and error at 10 percent, 50 percent, and 90 percent of span.
8. Analog output devices:
    a. Calibration range.
9. Discrete instrument input devices:
    a. Switch setting, contact action, and dead band.
    b. Valve position switches:
    c. Starter and drive auxiliary device contact response.
10. Discrete output devices:
    a. Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

F. Provide all test apparatus required at no extra cost.

G. Follow testing procedures recommended by the manufacturer and approved by Contractor.
    1. Conduct continuous 8-hour test under full load conditions.
    2. Replace parts which operate improperly.

## 3.07 OPERATIONAL TESTING

A. After completion of operator training, Contractor, under the supervision of Supplier, shall conduct operational tests.

B. Contractor, under the supervision of Supplier, shall demonstrate satisfactory operation of equipment and systems in actual operation.

C. County, under the supervision of Supplier, shall conduct operational test until steady state operation is achieved for at least 48-hours. It is acceptable for the supplier to be available remotely for the following time.

D. County will provide operations personnel, power, lime, water, and other consumables for duration of test.

E. Supplier shall immediately correct defects in material, workmanship, or equipment which became evident during operational test.

F. Defects in equipment identified during performance testing shall be repaired by the Supplier at no additional cost to Contractor.

G. Contractor, under the supervision of Supplier, shall repeat operational test when malfunctions or deficiencies cause shutdown or partial operation of the facility or results in performance that is less than specified.

## 3.08 PERFORMANCE TESTING

A. During operational test, the system will be tested for general performance to meet the conditions of the process design criteria.

B. If the results of the performance tests are unsatisfactory, the Contractor shall make the necessary modifications to comply with the requirements at no additional cost to the County.

C. The cost of the test shall be the responsibility of the Supplier.

## 3.09 CERTIFICATE OF PROPER INSTALLATION

A. Certificates issued at completion of functional testing,

B. Supplier shall furnish written report prepared and signed by manufacturer's authorized representative, certifying equipment:
   1. Report includes:
      a. Project name and number.
      b. Has been properly installed, adjusted, aligned, and lubricated.
      c. Is free of any stresses imposed by connecting piping or anchor bolts.
      d. Is suitable for satisfactory full-time operation under full load conditions.
      e. Operates within the allowable limits for vibration.
      f. Controls, protective devices, instrumentation, and control panels furnished as part of the equipment package are properly installed, calibrated, and functioning.
      g. Control logic for start-up, shutdown, sequencing, interlocks, and emergency shutdown have been tested and are properly functioning.

C. Supplier shall furnish written report prepared and signed by the electrical and/or instrumentation subcontractor certifying equipment:
   1. Report includes:
      a. Project name and number.
      b. Motor control logic that resides in motor control centers, control panels, and circuit boards furnished by the electrical and/or instrumentation subcontractor has been calibrated and tested and is properly operating.
      c. Control logic for equipment start-up, shutdown, sequencing, interlocks, and emergency shutdown has been tested and is properly operating.
      d. Co-sign the reports along with the manufacturer's representative and subcontractors.

## 3.10 SUPPLIER'S ONSITE SERVICES

A. Scope of the services shall include but not limited to the following tasks:
   1. Supplier shall provide:
      a. Onsite installation assistance.
      b. Onsite startup assistance prior to the performance test.
      c. Onsite operational assistance during the performance test.
      d. Time as required to provide County training as specified in this Section.
   2. Number of trips as required to ensure proper installation (time on-site shall be Monday through Friday, travel shall be accommodated on weekends or after 3:00 pm on Friday).
   3. Supplier shall respond to Contractor questions during the construction phase.

B. Supplier's representative shall be a qualified individual who has previously provided onsite services for the installation, testing, and start-up of Supplier's similar or identical system of similar size or larger.

## 3.11 TRAINING OF COUNTY'S PERSONNEL

A. Supplier shall provide operations and maintenance training for items of mechanical, electrical and instrumentation equipment.

B. Coordinate training sessions to prevent overlapping sessions. Arrange sessions so that individual operators and maintenance techs do not attend more than 2 sessions.

C. Provide Draft Operation and Maintenance Manual for specific pieces of equipment or systems prior to training session for that piece of equipment or system.

D. Satisfactorily complete functional testing before beginning operator training.

E. Following County's acceptance of Certificate of Proper Installation, Supplier shall perform a comprehensive training of County's personnel at the site.

F. Training provided by Supplier's representative shall consist of both classroom and field training:
   1. Classroom training shall consist of a minimum of 4 hours of lectures on the lime system operation and the maintenance requirements.
   2. Hands-on training shall take place before the performance test and shall consist of a minimum of 4 hours of training devoted to operation and maintenance of the lime system.

## 3.12 MANUFACTURER'S REPAIR SERVICES

A. Provide services of factory-trained representatives of the manufacturer to correct defective Work during the correction period.

B. Replacement parts or equipment installed during the correction period shall be equal or better than the original.

END OF SECTION