Snyderville Basin Water Reclamation District

# SNYDERVILLE BASIN WATER RECLAMATION DISTRICT
# PARK CITY, UTAH

## EAST CANYON WATER RECLAMATION FACILITY

## DEWATERING EQUIPMENT INSTALLATION

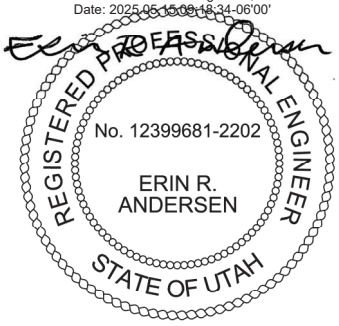
## PROJECT NO. 204042

## BID SUBMITTAL

## CONTRACT/TECHNICAL SPECIFICATIONS

## MAY 2025

Digitally signed by Erin R. Andersen
Contact Info: Carollo Engineers, Inc.
Date: 2025.05.15 09:18:34-06'00'

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**SNYDERVILLE BASIN WATER RECLAMATION DISTRICT**

**EAST CANYON WATER RECLAMATION FACILITY**
**DEWATERING EQUIPMENT INSTALLATION**

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**DOCUMENT 00100**

**INVITATION TO BID**

Snyderville Basin Water Reclamation District

2800 Homestead Road

Park City, Utah 84098

For the East Canyon Water Reclamation Facility Dewatering Equipment Installation

## ARTICLE 1 - BID OPENING

1.01 Notice is hereby given that sealed bids for the East Canyon Water Reclamation Facility (ECWRF) Dewatering Equipment Installation will be received at the Snyderville Basin Water Reclamation District (District) Administration Building located at 2800 Homestead Road, Park City, Utah 84098. Bids shall be date and time stamped before 3:00 p.m. on Wednesday, June 11, 2025, local time, at which time they will be opened and read aloud.

1.02 Prequalification of Bidders is required. Due to the specialized nature of the construction, the experience and qualifications of Bidders has been evaluated by the Owner. Only Bids submitted by Bidders previously determined by the Owner to be qualified will be considered. Bids received from Bidders who are not prequalified will be returned.

## ARTICLE 2 - DESCRIPTION OF THE PROJECT

2.01 You are invited to bid on Work comprising the installation of the ECWRF Dewatering Equipment. The Project is located at 2909 West Sackett Drive, Park City, Utah for the Snyderville Basin Water Reclamation District.

## ARTICLE 3 - BIDDING DOCUMENTS

3.01 All questions regarding bid documents and terms shall be e-mailed to the Engineer:

Erin Andersen, P.E.
e-mail: eandersen@carollo.com

3.02 A full set of Bidding Documents is available for examination at the Engineer's office located at:

Carollo Engineers
7090 S. Union Park Ave., Suite #600
Salt Lake City, UT 84047

## ARTICLE 4 - PRE-BID PERIOD CONFERENCE

4.01 A pre-bid period conference will be held at 10:00 a.m. on Wednesday, May 28, 2025, at the Snyderville Basin Water Reclamation District Administration Building located at 2800 Homestead Road, Park City, Utah 84098. A site tour will be conducted following the meeting. Attendance is recommended.

## ARTICLE 5 - OWNER'S RIGHTS

5.01 Owner reserves the right after opening Bids to reject any or all Bids, to waive any informality (non-responsiveness) in a Bid, or to make award to the lowest responsive, responsible Bidder and reject all other Bids, as it may best serve the interest of the Owner.

## ARTICLE 6 - LAWS AND REGULATIONS

6.01 Pursuant to Section 63G-6-103, Utah Procurement Code, “Invitation for bids” shall mean all documents, whether attached or incorporated by reference, utilized for soliciting bids.

Snyderville Basin Water Reclamation District

END OF DOCUMENT

**DOCUMENT 00200**

**INSTRUCTIONS TO BIDDERS**

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## ARTICLE 1 — DEFINED TERMS

1.01 Terms used in these Instructions to Bidders have the meanings indicated in the General Conditions. Additional terms used in these Instructions to Bidders have the meanings indicated below:

A. Issuing Office—The office from which the Bidding Documents are to be issued, and which registers plan holders.

B. Invitation to Bid—In accordance with Utah Procurement Code, Section 63G-6-103, "Invitation for bids" shall mean all documents, whether attached or incorporated by reference, utilized for soliciting bids.

## ARTICLE 2 — BIDDING DOCUMENTS

2.01 Bidder shall obtain a complete set of Bidding Requirements and proposed Contract Documents (together, the Bidding Documents). See the Agreement for a list of the Contract Documents. It is Bidder's responsibility to determine that it is using a complete set of documents in the preparation of a Bid. Bidder assumes sole responsibility for errors or misinterpretations resulting from the use of incomplete documents, by Bidder itself or by its prospective Subcontractors and Suppliers.

2.02 Bidding Documents are made available for the sole purpose of obtaining Bids for completion of the Project and permission to download or distribution of the Bidding Documents does not confer a license or grant permission or authorization for any other use. Authorization to download documents, or other distribution, includes the right for plan holders to print documents solely for their use, and the use of their prospective Subcontractors and Suppliers, provided the plan holder pays costs associated with printing or reproduction. Printed documents may not be re-sold under any circumstances.

2.03 Bidders may rely that sets of Bidding Documents are complete unless an omission is blatant. Registered plan holders will receive Addenda issued by Owner.

2.04 Owner has established a Bidding Documents Website as indicated in the Advertisement or invitation to bid. Owner requires that Bidder register as a plan holder with the issuing Office at such website and obtain a complete set of the Bidding Documents from such website.

2.05 Plan rooms (including construction information subscription services, and electronic and virtual plan rooms) may distribute the Bidding Documents or make them available for examination. Those prospective bidders that obtain an electronic (digital) copy of the Bidding Documents from a plan room are encouraged to register as plan holders from the Bidding Documents Website or Issuing Office. Owner is not responsible for omissions in Bidding Documents or other documents obtained from plan rooms, or for a Bidder's failure to obtain Addenda from a plan room.

2.06 Electronic documents:

A. When the Bidding Requirements indicate that electronic (digital) copies of the Bidding Documents are available, such documents will be made available to the Bidders as Electronic Documents in the manner specified.

1. Bidding Documents will be provided in Adobe PDF (Portable Document Format) (.pdf) that is readable by Adobe Acrobat Reader, latest version. It is the intent of the Engineer and Owner that such Electronic Documents are to be exactly

representative of the paper copies of the documents. However, because the Owner and Engineer cannot totally control the transmission and receipt of Electronic Documents nor the Contractor's means of reproduction of such documents, the Owner and Engineer cannot and do not guarantee that Electronic Documents and reproductions prepared from those versions are identical in every manner to the paper copies.

B. Unless otherwise stated in the Bidding Documents, the Bidder may use and rely upon complete sets of Electronic Documents of the Bidding Documents. However, Bidder assumes all risks associated with differences arising from transmission/receipt of Electronic Documents versions of Bidding Documents and reproductions prepared from those versions and, further, assumes all risks, costs, and responsibility associated with use of the Electronic Documents versions to derive information that is not explicitly contained in printed paper versions of the documents, and for Bidder's reliance upon such derived information.

## ARTICLE 3 — QUALIFICATIONS OF BIDDERS

3.01 Prequalification requirements:

A. Due to the specialized nature of the work, Prospective Bidders must be prequalified to submit a bid. The following Contractors are prequalified to submit bids:
   1. Alder Construction.
   2. Archer Western.
   3. Gerber.
   4. MGC Contractors.
   5. RSCI.

B. Bids will only be accepted from listed contractors.

## ARTICLE 4 — PRE-BID CONFERENCE

4.01 A non-mandatory pre-bid conference will be held at the time and location indicated in the Advertisement or invitation to bid where representatives of Owner and Engineer will be present to discuss the Project.

A. Bidders are encouraged to attend and participate in the conference; however, attendance at this conference is not required to submit a Bid.

B. Information presented at the pre-bid conference does not alter the Contract Documents.
   1. Owner will issue Addenda to make any changes to the Contract Documents that result from discussions at the pre-Bid conference.
   2. Information presented, and statements made at the pre-bid conference will not be binding or legally effective unless incorporated in an Addendum.

## ARTICLE 5 — SITE AND OTHER AREAS; EXISTING SITE CONDITIONS; EXAMINATION OF SITE; OWNER'S SAFETY PROGRAM; OTHER WORK AT THE SITE

5.01 Site and other areas:

A. The Site is identified in the Bidding Documents. By definition, the Site includes rights-of-way, easements, and other lands furnished by Owner for the use of the Contractor. Any additional lands required for temporary construction facilities, construction equipment, or storage of materials and equipment, and any access needed for such additional lands, are to be obtained and paid for by Contractor.

5.02 Site visit and testing by bidders:

A. Bidder is required to visit the Site and conduct a thorough visual examination of the Site and adjacent areas. During the visit the Bidder must not disturb any ongoing operations at the Site.

B. A Site visit is scheduled as part of the pre-bid conference.

C. Bidders visiting the Site are required to arrange their own transportation to the Site.

D. Access to the Site other than during a regularly scheduled Site visit must be coordinated through the following Owner or Engineer contact for visiting the Site: Marlo Davis (435-214-5231).

1. Bidder must conduct the required Site visit during normal working hours.

## ARTICLE 6 — BIDDER'S REPRESENTATIONS AND CERTIFICATIONS

6.01 Express representations and certifications in Bid Form, agreement:

A. The Bid Form that each Bidder will submit contains express representations regarding the Bidder's examination of Project documentation, Site visit, and preparation of the Bid, and certifications regarding lack of collusion or fraud in connection with the Bid. Bidder should review these representations and certifications and assure that Bidder can make the representations and certifications in good faith, before executing and submitting its Bid.

B. If Bidder is awarded the Contract, Bidder (as Contractor) will make similar express representations and certifications when it executes the Agreement.

## ARTICLE 7 — INTERPRETATIONS AND ADDENDA

7.01 Owner on its own initiative may issue Addenda to clarify, correct, supplement, or change the Bidding Documents.

7.02 Submit questions about the meaning or intent of the Bidding Documents to Engineer in writing. Contact information and submittal procedures for such questions are as follows:

A. Questions shall be submitted in writing to Erin Andersen, P.E. at eandersen@carollo.com.

7.03 Interpretations or clarifications considered necessary by Engineer in response to such questions will be issued by Addenda delivered to registered plan holders.

A. Questions received less than 10 days prior to the date for opening of Bids may not be answered.

7.04 Only responses set forth in an Addendum will be binding. Oral and other interpretations or clarifications will be without legal effect. Responses to questions are not part of the Contract Documents unless set forth in an Addendum that expressly modifies or supplements the Contract Documents.

## ARTICLE 8 — CONTRACT TIMES

8.01 The number of days within which, or the dates by which, the Work is to be (a) substantially completed and (b) ready for final payment, and (c) Milestones (if any) are to be achieved, are set forth in Document 00520 - Agreement Between Owner and Contractor.

8.02 Provisions for liquidated damages, if any, for failure to timely attain a Milestone, Substantial Completion, or completion of the Work in readiness for final payment, are set forth in Document 00520 - Agreement Between Owner and Contractor.

## ARTICLE 9 — SUBSTITUTE AND "OR EQUAL" ITEMS

9.01 Prices that Bidder sets forth in its Bid will be based on the presumption that the Contractor will furnish the materials and equipment specified or described in the Bidding Documents, as supplemented by Addenda.

A. Any assumptions regarding the possibility of post-Bid approvals of "or-equal" or substitution requests are made at Bidder's sole risk.

## ARTICLE 10 — SUBCONTRACTORS, SUPPLIERS, AND OTHERS

10.01 Submit list of the Subcontractors or Suppliers:

A. Submit Document 00434 - Proposed Subcontractors Form to Owner with a list of the Subcontractors or Suppliers proposed.
   1. List subcontractors or suppliers proposed who will perform work or labor or render services in an amount in excess of 1/2 of 1 percent of Contractor's total bid.

## ARTICLE 11 — PREPARATION OF BID

11.01 Document 00410 - Bid Form is included with the Bidding Documents.

A. Complete blanks on the Bid Form in ink.

B. Sign the Bid Form signed in ink with names printed in ink below the signatures.

C. Erasures or alterations must be initialed in ink by the person signing the Bid Form.

D. Indicate a Bid price for each section, Bid item, alternate, adjustment unit price item, and unit price item listed.

E. If the Bid Form expressly indicates that submitting pricing on a specific alternate item is optional, and Bidder elects to not furnish pricing for such optional alternate item, then Bidder may enter the words "No Bid" or "Not Applicable."

F. Unauthorized conditions, limitations, or modifications attached to the Bid will render it informal and may cause its rejection as being non-responsive.

G. Oral, telegraphic, faxed or telephone Bids or modifications will not be considered.

H. Alternative Bids will not be considered unless expressly called for in Document 00100 - Invitation to Bid.

11.02 If Bidder has obtained the Bidding Documents as Electronic Documents, then Bidder shall prepare its Bid on a paper copy of the Bid Form printed from the Electronic Documents version of the Bidding Documents.

A. The printed copy of the Bid Form must be clearly legible, printed on 8-1/2 inch by 11-inch paper and as closely identical in appearance to the Electronic Document version of the Bid Form as may be practical.

B. The Owner reserves the right to accept Bid Forms which nominally vary in appearance from the original paper version of the Bid Form, providing that required information and submittals are included with the Bid.

11.03 A Bid by a corporation must be executed in the corporate name by a corporate officer (whose title must appear under the signature), accompanied by evidence of authority to sign.

A. The corporate address and state of incorporation must be shown.

B. The corporate seal must be affixed and attested by the corporate secretary or an assistant corporate secretary.

11.04 A Bid by a partnership must be executed in the partnership name and signed by a partner (whose title must appear under the signature), accompanied by evidence of authority to sign.

A. The official address of the partnership must be shown.

11.05 A Bid by a limited liability company must be executed in the name of the firm by a member or other authorized person and accompanied by evidence of authority to sign.

A. The state of formation of the firm and the official address of the firm must be shown.

11.06 A Bid by an individual must show the Bidder's name and official address.

11.07 A Bid by a joint venture must be executed by an authorized representative of each joint venturer in the manner indicated on the Bid Form.

A. The joint venture must have been formally established prior to submittal of a Bid, and the official address of the joint venture must be shown.

11.08 The Bid must contain an acknowledgment of receipt of Addenda, the numbers of which must be filled in on the Bid Form.

11.09 The Bid must contain evidence of Bidder's authority to do business in the state where the Project is located, or Bidder must certify in writing that it will obtain such authority within the time for acceptance of Bids and attach such certification to the Bid.

11.10 Bidder's state contractor license number must be shown on the Bid Form.

11.11 Postal and e-mail addresses and telephone number for communications regarding the Bid must be shown.

11.12 Bid preferences:

A. Submit with bid Document 00453 - Bid Preferences to certify the preferences to which the Bidder may be entitled in accordance with Utah Procurement Code, Section 63G-6-404.

B. In accordance with Utah Code, Section 34-30-1, in employing workmen in the construction of public works by the state of Utah or any county or municipality, or by persons contracting with the state of Utah or any county or municipality, preference shall be given citizens of the United States, or those having declared their intention of becoming citizens.

C. In accordance with Utah Code, Section 34-30-1, if the provisions are not complied with, this Agreement shall be void.

## ARTICLE 12 — BASIS OF BID

12.01 Lump sum:

A. Bidders must submit a Bid on a lump sum basis as set forth in the Bid Form.

12.02 Allowances:

A. For cash allowances the Bid price must include such amounts as the Bidder deems proper for Contractor's overhead, costs, profit, and other expenses on account of cash allowances, if any, named in the Contract Documents, in accordance with Document 00700 - General Conditions.

## ARTICLE 13 — SUBMITTAL OF BID

13.01 Submit bids and required bid documents under the terms of the Bid Form.

A. Hardcopy:
   1. Unbound documents.
   2. Bid must be enclosed in a plainly marked package with the Project title, and the name and address of Bidder.
      a. If a Bid is sent by mail or other delivery system, the sealed envelope containing the Bid must be enclosed in a separate package plainly marked on the outside with the notation “BID ENCLOSED”.
      b. A mailed Bid must be addressed to the location designated in the Advertisement.

13.02 A Bid must be received no later than the date and time prescribed and at the place indicated in the Advertisement or invitation to bid.

13.03 Bids received after the date and time prescribed for the opening of bids, or not submitted at the correct location or in the designated manner, will not be accepted and will be returned to the Bidder unopened.

## ARTICLE 14 — MODIFICATION AND WITHDRAWAL OF BID

14.01 An unopened Bid may be withdrawn by an appropriate document duly executed in the same manner that a Bid must be executed and delivered to the place where Bids are to be submitted prior to the date and time for the opening of Bids.

A. Upon receipt of such notice, the unopened Bid will be returned to the Bidder.

14.02 If a Bidder wishes to modify its Bid prior to Bid opening, Bidder must withdraw its initial Bid in the manner specified and submit a new Bid prior to the date and time for the opening of Bids.

14.03 If within 24 hours after Bids are opened any Bidder files a duly signed written notice with Owner and promptly thereafter demonstrates to the reasonable satisfaction of Owner that there was a material and substantial mistake in the preparation of its Bid, the Bidder may withdraw its Bid, and the Bid security will be returned.

A. Thereafter, if the Work is rebid, the Bidder will be disqualified from further bidding on the Work.

## ARTICLE 15 — OPENING OF BIDS

15.01 Bids will be opened at the time and place indicated in the advertisement or invitation to bid and, unless obviously non-responsive, read aloud publicly.

A. An abstract of the amounts of the base Bids and major alternates, if any, will be made available to Bidders after the opening of Bids.

## ARTICLE 16 — BIDS TO REMAIN SUBJECT TO ACCEPTANCE

16.01 Bids will remain subject to acceptance for the period of time stated in the Bid Form, but Owner may, in its sole discretion, release any Bid and return the Bid security prior to the end of this period.

## ARTICLE 17 — EVALUATION OF BIDS AND AWARD OF CONTRACT

17.01 Owner reserves the right to reject any or all Bids, including without limitation, nonconforming, nonresponsive, unbalanced, or conditional Bids.

A. Owner also reserves the right to waive all minor Bid informalities not involving price, time, or changes in the Work.

17.02 Owner will reject the Bid of any Bidder that Owner finds, after reasonable inquiry and evaluation, to not be responsible.

17.03 If Owner awards the contract for the Work, such award will be to the responsible Bidder submitting the lowest responsive Bid.

17.04 Evaluation of Bids:

A. In evaluating Bids, Owner will consider whether the Bids comply with the prescribed requirements, and such alternates, unit prices, and other data, as may be requested in the Bid Form or prior to the Notice of Award.

B. In the comparison of Bids, alternates will be applied in the same order of priority as listed in the Bid Form.
   1. To determine the Bid prices for purposes of comparison, Owner will announce to bidders a “Base Bid plus alternates” budget after receiving Bids, but prior to opening them.
   2. For comparison purposes alternates will be accepted, following the order of priority established in the Bid Form, until doing so would cause the budget to be exceeded.
   3. After determination of the Successful Bidder based on this comparative process and on the responsiveness, responsibility, and other factors set forth in these Instructions, the award may be made to said Successful Bidder on its base Bid and any combination of its additive alternate Bids for which Owner determines funds will be available at the time of award.
   4. In the event the Base Bids of all bidders exceeds the project control budget, the Owner reserves the right to make and award to the apparent Low Bidder if additional funds are available.

C. For the determination of the apparent low Bidder when unit price bids are submitted, Bids will be compared on the basis of the total of the products of the estimated quantity of each item and unit price Bid for that item, together with any lump sum items.

## ARTICLE 18 — BONDS AND INSURANCE

18.01 Document 00700 - General Conditions sets forth Owner's requirements as to performance and payment bonds, other required bonds (if any), and insurance.

A. When the Successful Bidder delivers the executed Agreement to Owner, it must be accompanied by required bonds and insurance documentation.

18.02 Bid Security, requirements of providing bid bonds as part of the bidding process are specified in this document.

## ARTICLE 19 — SIGNING OF AGREEMENT

19.01 When Owner issues a Notice of Award to the Successful Bidder, it will be accompanied by the unexecuted counterparts of the Agreement along with the other Contract Documents as identified in the Agreement.

A. Within 15 days thereafter, Successful Bidder must execute and deliver the required number of counterparts of the Agreement and any bonds and insurance documentation required to be delivered by the Contract Documents to Owner.

B. Within 10 days thereafter, Owner will deliver 1 fully executed counterpart of the Agreement to Successful Bidder, together with printed and electronic copies of the Contract Documents as stated the General Conditions.

## ARTICLE 20 — SALES AND USE TAXES

20.01 Contractor, Subcontractors, and other persons who provide labor, Equipment, Materials, supplies, or services shall comply with all applicable state and local laws, including licensing requirements and requirements for payment of sales and use tax, in accordance with section 7.09 of the General Conditions.

## ARTICLE 21 — CONTRACTS TO BE ASSIGNED

21.01 No Contracts will be assigned by Owner to Contractor as part of the project.

END OF DOCUMENT

# DOCUMENT 00410

# BID FORM

PROJECT IDENTIFICATION:

Snyderville Basin Water Reclamation District

East Canyon Water Reclamation Facility Expansion Project

THIS BID IS SUBMITTED BY:

_____

(Bidder)

_____

(Bidder Address)

_____

THIS BID IS SUBMITTED TO:

Snyderville Basin Water Reclamation District
2800 Homestead Road
Park City, UT 84098

## ARTICLE 1 - BID RECIPIENT

1.01 The undersigned Bidder proposes and agrees, if this Bid is accepted, to enter into an agreement with Owner in the form included in the Bidding Documents to perform all Work as specified or indicated in the Bidding Documents within the specified time and for the price indicated in this Bid and in accordance with the other terms and conditions of the Bidding Documents.

## ARTICLE 2 - BIDDER'S ACKNOWLEDGMENT

2.01 Bidder accepts all of the terms and conditions of Document 00100 - Invitation to Bid and Document 00200 - Instructions to Bidders. The Bid will remain subject to acceptance for 30 days after the Bid opening, or for such longer period of time that Bidder may agree to in writing upon request of Owner.

## ARTICLE 3 - BIDDER'S REPRESENTATIONS

3.01 In submitting this Bid, Bidder represents that:

A. Bidder has examined and carefully studied the Bidding Documents, the other related data identified in the Bidding Documents, and the following Addenda, receipt of which is hereby acknowledged.

ADDENDA

No. _____ Dated _____

No. _____ Dated _____

No. _____ Dated _____

No. _____ Dated _____

No. _____ Dated _____

No. _____ Dated _____

B. Bidder has visited the site and become familiar with and satisfied itself as to the general, local, and site conditions that may affect cost, progress, and performance of the Work.

C. Bidder is familiar with and has satisfied itself as to all Federal, state, and local Laws and Regulations and Permits that may affect cost, progress, and performance of the Work.

D. Bidder does not consider that any further examinations, investigations, explorations, tests, studies, or data are necessary for the determination of this Bid for performance of the Work at the price(s) bid and within the times and in accordance with the other terms and conditions of the Bidding Documents.

E. Bidder is aware of the general nature of work to be performed by Owner and others at the Site, including Air Med personnel, that impacts the Work as indicated in the Bidding Documents.

F. Bidder has given Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Bidder has discovered in the Bidding Documents, and the written resolution thereof by Engineer is acceptable to Bidder.

G. The Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for the performance of the Work for which this Bid is submitted.

## ARTICLE 4 - BIDDER'S CERTIFICATION

4.01 Bidder further represents:

A. This Bid is genuine and not made in the interest of or on behalf of any undisclosed individual or entity and is not submitted in conformity with any agreement or rules of any group, association, organization, or corporation.

B. Bidder has not directly or indirectly induced or solicited any other Bidder to submit a false or sham bid.

C. Bidder has not solicited or induced any individual or entity to refrain from bidding.

D. Bidder has not sought by collusion to obtain for itself any advantage over any other Bidder or over Owner.

E. Bidder has not engaged in corrupt, fraudulent, collusive, or coercive practices in competing for the Contract. For the purposes of this paragraph:
   1. "Corrupt practice" means the offering, giving, receiving, or soliciting of anything of value likely to influence the action of a public official in the bidding process.
   2. "Fraudulent practice" means an intentional misrepresentation of facts made:
      a. To influence the bidding process to the Owner's detriment.
      b. To establish bid prices at artificial non-competitive levels, or
      c. To deprive Owner of the benefits of free and competitive bidding process.
   3. "Collusive practice" means a scheme or arrangement between 2 or more Bidders to establish bid prices at artificial, non-competitive levels.
   4. "Coercive practice" means harming or threatening to harm persons or their property.

## ARTICLE 5 - ASSIGNMENTS AND ALLOWANCES

5.01 Bidder shall provide the Owner with allowances as indicated on the Bid Form. The Owner, at Owner's option, will use these allowances as described in Section 01210 - Allowances. The Contractor will submit invoices to the Owner with pay requests. The allowance shall be included in the Itemized Bid in addition to the cost of the Work in accordance with Section 01210 - Allowances.

## ARTICLE 6 - BASIS OF BID

6.01 Bidder will complete the Work in accordance with the Contract Documents for the following price(s):

| Bid Form<br>ECWRF Expansion Project | | |
|---|---|---|
| **Lump Sum Bid Items** | | |
| | **Description** | **Total Price** |
| 1. | Lump Sum Amount for Installation of Dewatering Equipment. | |
| 2. | Allowances as specified in Section 01210 - Allowances. | $125,000 |
| 3. | Total Lump Sum Bid<br>(sum of items 1-2)<br><br>_____<br>(Total Bid Amount in words) | |

## ARTICLE 7 - TIME OF COMPLETION

7.01 Bidder agrees that the Work will be substantially completed and ready for final payment in accordance with paragraph 14.07.B of the General Conditions on or before the dates or within the number of calendar days as specified in Document 00520 - Agreement Forms.

7.02 Bidder accepts the provisions of the Agreement as to liquidated damages in the event of failure to complete the Work within the times specified above, which shall be as specified in Document 00520 - Agreement Forms.

## ARTICLE 8 - ATTACHMENTS TO THIS BID

8.01 The following documents are attached to and made a condition of this Bid:

A. Document 00434 - List of Subcontractors.

B. Document 00444 - Experience Modification Rate.

C. Document 00453 - Bid Preferences, pursuant to Utah Procurement Code.

D. Document 00454 - Bid Certification for the Payment of Utah State and Local Taxes.

E. Document 00458 - Certification of Drug-Free Workplace Requirements.

**ARTICLE 9 - BID SUBMITTAL**

SUBMITTED on _____, 2025.

State Contractor License Number _____.

If Bidder is:

An Individual

Name (typed or printed): _____

By: _____

(Individual's signature)

Doing business as: _____

Business address: _____

Phone Number: (  ) _____ FAX Number: (  ) _____

A Partnership

Partnership Name: _____

By: _____

(Signature of general partner -- attach evidence of authority to sign)

Name (typed or printed): _____

Business address: _____

Phone Number: (  ) _____ FAX Number: (  ) _____

A Corporation

Corporation Name: _____

State of Incorporation: _____

Type (General Business, Professional, Service, Limited Liability):_____

By: _____

(Signature -- attach evidence of authority to sign)

Name (typed or printed): _____

Title: _____

Attest: _____

(Signature of Corporate Secretary, Acting Secretary or other officer)

Business address: _____

Phone Number: (  )_____ FAX Number: (  )_____

Date of Qualification to do business is _____

A Joint Venture

Joint Venturer Name: _____

By: _____

(Signature of joint venture partner -- attach evidence of authority to sign)

Name (typed or printed): _____

Title: _____

Business address: _____

Phone Number: (  )_____ FAX Number: (  )_____

Joint Venturer Name: _____

By: _____

(Signature of joint venture partner -- attach evidence of authority to sign)

Name (typed or printed): _____

Title: _____

Business address: _____

Phone Number: (  )_____ FAX Number: (  )_____

Phone and FAX Number, and Address for receipt of official communications:

_____

(Each joint venturer must sign. The manner of signing for each individual, partnership, and corporation that is a party to the joint venture should be in the manner indicated above.)

END OF DOCUMENT

**DOCUMENT 00434**

**LIST OF SUBCONTRACTORS**

The Bidder shall list below the names and location of place of business of each subcontractor who will perform Work or labor or who will render service to the prime Contractor in or about the construction of the Work or improvement, or a subcontractor duly licensed who, under subcontract to the prime Contractor, specially fabricates and installs a portion of the Work or improvement according to detailed Drawings contained in the Contract Documents, in an amount in excess of 1/2 of 1 percent of the prime Contractor's total Bid. After the opening of Bids, no changes or substitutions will be allowed except as otherwise provided by law. The listing of more than one subcontractor for each item of Work to be performed with the words "and/or" will not be permitted. The Bidder's attention is directed to the provisions of paragraph 6.06.B.1 of the Supplementary Conditions, which stipulates the percent of the Work to be performed with the Bidder's own forces. Failure to comply with this requirement may render the Bid as non-responsive and may cause its rejection.

| Work to be Performed | Contractor License Number | Percent of Total Contract | Subcontractor's Name, Address, and Contact Person |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

BIDDER

_____

(Signature)

_____

(Date)

END OF DOCUMENT

## DOCUMENT 00444

## EXPERIENCE MODIFICATION RATE

### ARTICLE 1 - CONTRACTOR'S SAFETY PERFORMANCE AND PROGRAM

1.01 Workers' Compensation Insurance - Experience Modification Rate (EMR):

A. Provide the following data.

| | Policy Year | Modification Rate |
|---|---|---|
| Most Recent Policy Year | _____ | _____ |
| 1 year previously | _____ | _____ |
| 2 years previously | _____ | _____ |

B. Answer the following questions.
1. Are the above rates interstate or intrastate? _____.
2. If intrastate, which state? _____.
3. If your EMR is exactly 1.0 for any policy year, it is because your firm is (or was) too new or too small to have an EMR calculated?

Yes _____ No _____

C. Provide documentation by one of the following methods:
1. Furnish a letter from your insurance agent, insurance carrier, or state fund (on their letterhead) verifying the EMR data for the last 3 rating periods.
   a. If you do not have an interstate rating, obtain your intrastate EMRs.
2. Furnish a copy of the last 3 years' Experience Rating Calculation Sheets from your insurance carrier.
3. If you are in a "state fund," such as Ohio or West Virginia, furnish a copy of the state's last 3 years annual statement page that shows the modification rate and the coverage period.

END OF DOCUMENT

## DOCUMENT 00453

## BID PREFERENCES

1. Did you claim a bid preference under Utah Procurement Code 63G-6-404 — Preference for Providers of State Products?

   [ ] Yes [ ] No

   If so, are you submitting proof that the goods, supplies, equipment, materials, or printing offered are produced, manufactured, mined, grown or performed in Utah?

   [ ] Yes [ ] No

2. Did you claim a bid preference under Utah Procurement Code 63G-6-405 — Preference for Resident Contractors?

   [ ] Yes [ ] No

   If so, are you submitting proof of qualifications as a Resident Contractor?

   [ ] Yes [ ] No

3. Did you claim a bid preference under Utah Procurement Code 63G-6-406 — Preference for Recycled Paper and Paper Products?

   [ ] Yes [ ] No

   If so, are you submitting proof of entitlement under this Code section?

   [ ] Yes [ ] No

BIDDER

_____

(Signature)

_____

(Date)

END OF DOCUMENT

## DOCUMENT 00454

## BID CERTIFICATION FOR THE PAYMENT OF STATE AND LOCAL TAXES

KNOW ALL MEN BY THESE PRESENTS, THAT the Bidder does hereby stipulate and certify that the Bidder has paid Utah state and local taxes for 5 successive years before submitting this Bid to Snyderville Basin Water Reclamation District, entitled East Canyon Water Reclamation Facility Expansion Project.

[ ] Yes [ ] No

BIDDER

_____

(Signature)

_____

(Date)

END OF DOCUMENT

# DOCUMENT 00458

# CERTIFICATION OF DRUG-FREE WORKPLACE REQUIREMENTS

## ARTICLE 1 - BIDDER CERTIFICATIONS

1.01 The Bidder certifies that it will or will continue to provide a drug-free workplace by:

A. Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the Bidder's workplace and specifying the actions that will be taken against employees for violation of such prohibition.
   1. Making it a requirement that each employee to be engaged in the performance of the contract be given a copy of the statement.
   2. Notifying the employee in the statement that, as a condition of employment under the Contract, the employee will:
      a. Abide by the terms of the statement.
      b. Notify the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace no later than 5 calendar days after such conviction.
         1) Notifying the Owner in writing within 10 calendar days after receiving notice from an employee or otherwise receiving actual notice of such conviction.
         2) Taking 1 of the following actions, within 30 calendar days of receiving notice, with respect to any employee who is so convicted:
            a) Taking appropriate personnel action against such an employee, up to and including termination, consistent with the requirements of Federal and State law.
            b) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purpose by a Federal, State or local health, law enforcement, or other appropriate agency.
      c. Notify the employee that in the event of a major accident/incident resulting in loss of life, injury or damage to the facility, or equipment, all personnel involved shall be required to submit to substance testing as soon as possible after the incident, but not more than 4 hours after the incident.

B. Establishing an ongoing drug-free awareness program to inform employees about:
   1. The dangers of drug abuse in the workplace.
   2. The Bidder's policy of maintaining a drug-free workplace.
   3. Any available drug counseling, rehabilitation, and employee assistance programs.
   4. The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace.

C. Making a good faith effort to continue to maintain a drug-free workplace through implementation of the requirements stated in this Document.

**ARTICLE 2 - WORK LOCATIONS**

2.01 The Bidder may insert in the space provided below the site(s) for the performance of work done in connection with this Contract:

A. Place(s) of Performance: (Street address, city, county, state, zip code):

_____

_____

_____

BIDDER

_____

(Signature)

_____

(Date)

END OF DOCUMENT

**DOCUMENT 00510**

**NOTICE OF AWARD**

Date _____, 2025

To: _____
(Bidder)

Address: _____

_____

Project: East Canyon Water Reclamation Facility Dewatering Equipment Installation

You are hereby notified that your Bid dated _____, 2025, for the above Contract has been considered. You are the apparent successful Bidder and are being considered for the award of a contract for the above-named Project.

The Bid Price of your contract is $_____

_____ Dollars

Two copies of Document 00520 - Agreement Form accompany this Notice of Award.

Unless otherwise indicated, you must respond within 15 days of the date of this Notice of Award; that is, by _____, 2025.

1. You must deliver to the Owner 2 fully executed copies of Document 00520 - Agreement Form.

2. You must deliver with the executed Agreement such Bonds and certificates of insurance as specified in Article 6 of the General Conditions.

3. To comply with the insurance requirements to endorse the Owner, the Engineer, and the Owner's Consultant as additional insureds, the following statement must appear on each of the insurance certificates:

   "The Snyderville Basin Water Reclamation District, its officials, employees, agents, Engineer and Consultant are named as additional insureds as regards Owner Project East Canyon Water Reclamation Facility Expansion Project."

4. You must also deliver with the executed Agreement, copies of all current Business Licenses for you as General Contractor and for all Subcontractors working on the Project.

Failure to comply with these conditions within the time specified will entitle the Owner to consider your Bid abandoned, to annul this Notice of Award, and to declare your Bid security forfeited.

After award of contract by the Snyderville Basin Water Reclamation District, the Owner will return to you 1 fully signed Document 00520 - Agreement Form.

Snyderville Basin Water Reclamation District

_____

(Signature)

_____

(Date)

Snyderville Basin Water Reclamation District
2800 Homestead Road
Park City, Utah 84098

END OF DOCUMENT

**DOCUMENT 00520**

**AGREEMENT FORM**

**THIS AGREEMENT** is by and between Snyderville Basin Water Reclamation District (hereinafter called Owner) and _____ (hereinafter called Contractor).

Owner and Contractor, in consideration of the mutual covenants hereinafter set forth, agree as follows:

## ARTICLE 1 - THE PROJECT

1.01 The Project for which the Work under the Contract Documents may be the whole or only a part is generally described as follows: East Canyon Water Reclamation Facility Dewatering Equipment Installation.

## ARTICLE 2 - WORK

2.01 Contractor shall complete all Work as specified or indicated in the Contract Documents for completion of the Project.

## ARTICLE 3 - ENGINEER

3.01 The Engineer, Carollo Engineers, Inc., is to act as Owner's representative, assume all duties and responsibilities, and have the rights and authority assigned to Engineer in the Contract Documents in connection with the completion of the Work in accordance with the Contract Documents, unless otherwise modified in the Supplementary Conditions.

## ARTICLE 4 - CONTRACT TIMES

4.01 Time of the essence:

A. All time limits for Milestones, if any, Substantial Completion, and completion and readiness for final payment as stated in the Contract Documents are of the essence of the Contract.

4.02 Days to achieve substantial completion and final payment:

A. The Work will be substantially completed by the following dates when the Contract Times commence to run as provided in Article 4 of the General Conditions, and completed and ready for final payment in accordance with Article 15 of the General Conditions:

| | **Substantial Completion Date** | **Final Completion Date** |
|---|---|---|
| Complete Project | 120 Calendar Days | 30 Days from Substantial Completion |

4.03 Liquidated damages:

A. Contractor and Owner recognize that time is of the essence of this Agreement and that Owner will suffer financial loss if the Work is not completed within the times specified in this Document, plus any extensions thereof allowed in accordance with Article 11 of the General Conditions.

B. The parties also recognize that it will be impracticable to determine actual damages which Owner will sustain in the event of or by reason of the delay. Accordingly, instead of requiring any such proof, Owner and Contractor agree that as liquidated damages for delay (but not as a penalty) Contractor shall pay Owner $500 for each day that expires after the specified time stated in this Document for substantial completion until the Work is substantially complete.

C. After substantial completion, if Contractor shall neglect, refuse, or fail to complete the remaining Work within the contract time or any proper extension thereof granted by Owner, Contractor shall pay Owner $250 for each day that expires after the time specified in this Document for completion and readiness for final payment until the Work is completed and ready for final payment.

D. It is further agreed that the amount stipulated for liquidated damages per day of delay is a reasonable estimate of the damages that would be sustained by Owner, and Contractor agrees to pay such liquidated damages as provided in this Document. In case the liquidated damages are not paid, Contractor agrees that Owner may deduct the amount thereof from any money due or that may become due to Contractor by progress payments or otherwise under the Agreement, or if said amount is not sufficient, recover the total amount.

4.04 Environmental damages:

A. The Contractor and the Owner acknowledge that the Owner must be able to maintain existing plant operations during construction in order to meet the requirements of the Owner's UPDES Permit. It is the responsibility of Contractor to take any and all actions and precautions necessary to prevent the release of untreated or partially treated wastewater.

B. Accordingly, if Owner has a violation or potential violation of Owner’s UPDES permit, that is caused by the Contractor's failure to comply with the construction specifications or Contractor’s failure to take any actions or precautions to prevent the release of untreated or partially treated wastewater, the Contractor shall be responsible for and shall indemnify the Owner against any and all damages (including fines, penalties, legal fees and costs, and/or remediation efforts) resulting from such violation or potential violation of Owner’s UPDES permit.

## ARTICLE 5 - CONTRACT PRICE

5.01 Owner shall pay Contractor for completion of the Work in accordance with the Contract Documents an amount in current funds equal to the sum of the amounts determined pursuant to requirements listed below:

A. For all Work, a lump sum price of:

| _____ | $ _____ |
|---|---|
| (use words) | (figure) |

1. All specific cash allowances are included in the above price and have been computed in accordance with paragraph 13.02 of the General Conditions.

## ARTICLE 6 - PAYMENT PROCEDURES

6.01 Submittal and processing of payments:

A. Contractor shall submit Applications for Payment in accordance with Article 15 of the General Conditions. Applications for Payment will be processed by Engineer as provided in the General Conditions.

6.02 Progress payments; retainage:

A. Owner shall make progress payments on account of the Contract Price on the basis of Contractor's Applications for Payment on or before the first day of each month during performance of the Work as provided in paragraphs below. All such payments will be measured by the schedule of values established in paragraph 2.03 of the General Conditions (and in the case of Unit Price Work based on the number of units completed) or, in the event there is no schedule of values, as provided in the General Requirements:
   1. Pursuant to Utah Code 13-8-5, prior to Substantial Completion, progress payments will be made in an amount equal to the percentage indicated below but, in each case, less the aggregate of payments previously made and less such amounts as Engineer may determine or Owner may withhold, in accordance with paragraph 14.02 of the General Conditions:
      a. Progress payment of 95 percent of Work completed (with the balance being retainage). If the Work has been 50 percent completed as determined by Engineer, and if the character and progress of the Work have been satisfactory to Owner and Engineer, Owner, on recommendation of Engineer, may determine that as long as the character and progress of the Work remain satisfactory to them, there will be no retainage on account of Work subsequently completed, in which case the remaining progress payments prior to Substantial Completion will be in an amount equal to 100 percent of the Work completed less the aggregate of payments previously made; and
      b. Progress payment of 95 percent of cost of materials and equipment not incorporated in the Work (with the balance being retainage).

2. Pursuant to Utah Code 13-8-5, upon Substantial Completion, Owner shall pay an amount sufficient to increase total payments to Contractor to 100 percent of the Work completed, less such amounts as Engineer shall determine in accordance with Article 15 of the General Conditions and less 200 percent of Engineer's estimate of the value of Work to be completed or corrected as shown on the tentative list of items to be completed or corrected attached to the certificate of Substantial Completion.

6.03 Final payment:

A. Upon final completion and acceptance of the Work, Owner shall pay the remainder of the Contract Price as recommended by Engineer in accordance with Article 15 of the General Conditions.

## ARTICLE 7 - INTEREST

7.01 All moneys not paid when due as provided in Article 15 of the General Conditions shall bear interest at the current interest rate.

## ARTICLE 8 - CONTRACTOR'S REPRESENTATIONS

8.01 In order to induce Owner to enter into this Agreement, Contractor makes the following representations:

A. Contractor has examined and carefully studied the Contract Documents and the other related data identified in the Bidding Documents.

B. Contractor has visited the Site and become familiar with and is satisfied as to the general, local, and Site conditions that may affect cost, progress, and performance of the Work.

C. Contractor is familiar with and is satisfied as to all federal, state, and local Laws and Regulations that may affect cost, progress, and performance of the Work.

D. Contractor has carefully studied all:
1. Reports of explorations and tests of subsurface conditions at or contiguous to the Site and all drawings of physical conditions in or relating to existing surface or subsurface structures at or contiguous to the Site (except Underground Facilities) which have been identified in paragraph 5.03 of the Supplementary Conditions as containing reliable “technical data.”
2. Reports and drawings of a Hazardous Environmental Condition, if any, at the Site which has been identified in paragraph 5.06 of the Supplementary Conditions as containing reliable “technical data.”

E. Contractor has considered the information known to Contractor; information commonly known to contractors doing business in the locality of the Site; information and observations obtained from visits to the Site; the Contract Documents; and the Site-related reports and drawings identified in the Contract Documents, with respect to the effect of such information, observations, and documents on:
   1. The cost, progress, and performance of the Work.
   2. The means, methods, techniques, sequences, and procedures of construction to be employed by Contractor, including any specific means, methods, techniques, sequences, and procedures of construction expressly required by the Contract Documents.
   3. Contractor's safety precautions and programs.

F. Contractor does not consider that any further examinations, investigations, explorations, tests, studies, or data are necessary for the performance of the Work at the Contract Price, within the Contract Times, and in accordance with the other terms and conditions of the Contract Documents.

G. Contractor is aware of the general nature of work to be performed by Owner and others at the Site that relates to the Work as indicated in the Contract Documents.

H. Contractor has given Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Contractor has discovered in the Contract Documents, and the written resolution thereof by Engineer is acceptable to Contractor.

I. The Contract Documents are generally sufficient to indicate and convey understanding of all terms and conditions for performance and furnishing of the Work.

## ARTICLE 9 - CONTRACT DOCUMENTS

9.01 Contents:

A. The Contract Documents consist of the following:
   1. This Document.
   2. Document 00700 - General Conditions.
   3. Document 00800 - Supplementary Conditions.
   4. Specifications.
   5. Drawings.
   6. Addenda (numbers _____ to _____, inclusive).
   7. Exhibits to this Agreement (enumerated as follows):
      a. Document 00410 - Bid Forms.
   8. The following which may be delivered or issued on or after the Effective Date of the Agreement and are not attached hereto:
      a. Document 00550 - Notice to Proceed.
      b. Written Amendments.
      c. Work Change Directives.
      d. Field Order(s).

B. There are no Contract Documents other than those listed above in this Document.

C. The Contract Documents may only be amended, modified, or supplemented as provided in Article 11 of the General Conditions.

9.02 The statute of limitations for actions with respect to the contract are set forth in Utah Procurement Code 63G-6-817.

## ARTICLE 10 - MISCELLANEOUS

10.01 Terms:

A. Terms used in this Agreement will have the meanings indicated in the General Conditions.

10.02 Assignment of Contract:

A. No assignment by a party hereto of any rights under or interests in the Contract will be binding on another party hereto without the written consent of the party sought to be bound; and, specifically but without limitation, moneys that may become due and moneys that are due may not be assigned without such consent (except to the extent that the effect of this restriction may be limited by law), and unless specifically stated to the contrary in any written consent to an assignment, no assignment will release or discharge the assignor from any duty or responsibility under the Contract Documents.

10.03 Successors and assigns:

A. Owner and Contractor each binds itself, its partners, successors, assigns, and legal representatives to the other party hereto, its partners, successors, assigns, and legal representatives in respect to all covenants, agreements, and obligations contained in the Contract Documents.

10.04 Severability:

A. Any provision or part of the Contract Documents held to be void or unenforceable under any Law or Regulation shall be deemed stricken, and all remaining provisions shall continue to be valid and binding upon Owner and Contractor, who agree that the Contract Documents shall be reformed to replace such stricken provision or part thereof with a valid and enforceable provision that comes as close as possible to expressing the intention of the stricken provision.

10.05 Contractor's Certifications:

A. Contractor certifies that it has not engaged in corrupt, fraudulent, collusive, or coercive practices in competing for or in executing the Contract.
   1. "Corrupt practice" means the offering, giving, receiving, or soliciting of anything of value likely to influence the action of a public official in the bidding process or in the Contract execution.

2. “Fraudulent practice” means an intentional misrepresentation of facts made:
   a. To influence the bidding process or the execution of the Contract to the detriment of Owner.
   b. To establish Bid or Contract prices at artificial non-competitive levels.
   c. To deprive Owner of the benefits of free and open competition.
3. “Collusive practice” means a scheme or arrangement between 2 or more Bidders, with or without the knowledge of Owner, a purpose of which is to establish Bid prices at artificial, non-competitive levels.
4. “Coercive practice” means harming or threatening to harm, directly or indirectly, persons or their property to influence their participation in the bidding process or affect the execution of the Contract.

IN WITNESS WHEREOF, Owner and Contractor have signed this Agreement. Counterparts have been delivered to Owner and Contractor. All portions of the Contract Documents have been signed or have been identified by Owner and Contractor or on their behalf.

This Agreement will be effective on _____, 2025 (which is the Effective Date of the Agreement).

| Owner: | Contractor: |
|---|---|
| _____ | _____ |
| By: _____ | By: _____ |
| Title: _____ | Title: _____ |
| _____ | (If Contractor is a corporation, a partnership, or a joint venture, attach evidence of authority to sign.) _____ |
| Attest: _____ | Attest: _____ |
| Title: _____ | Title: _____ |
| Address for giving notices: | Address for giving notices: |
| _____ | _____ |
| _____ | _____ |
| _____ | _____ |
| | License No. _____ (Where applicable) |

Agent for service of process: _____

_____

| Designated Representative: | Designated Representative: |
|---|---|
| Name: _____ | Name: _____ |
| Title: _____ | Title: _____ |
| Address: _____ | Address: _____ |
| _____ | _____ |
| Phone: _____ | Phone: _____ |
| _____ | _____ |

END OF DOCUMENT

**DOCUMENT 00550**

**NOTICE TO PROCEED**

To: _____

Project: East Canyon Water Reclamation Facility (ECWRF) Dewatering Equipment Installation

Construction Contract Number: 10841B.30

Amount of Contract: _____

You are hereby notified to commence work on the referenced Contract on or before _____, 2025, and shall complete all of the work of said Contract required for Substantial Completion within 120 calendar days.

Document 00520 - Agreement Form, provides for an assessment of liquidated damages for each consecutive calendar day after the date for Substantial Completion and Final Completion as calculated in the Contract Documents that the work remains incomplete.

A preconstruction conference will be held at 10:00 a.m. on _____ at the Snyderville Basin Water Reclamation District ECWRF Training Building. Representatives of Owner and Engineer will be present to discuss the project. Contractor is required to attend and participate in the conference.

Owner

_____

(Signature)

_____

(Date)

ACCEPTANCE OF NOTICE

Receipt of the foregoing Notice to Proceed is hereby acknowledged by _____ this _____ day of _____, 2025.

Contractor

_____

(Signature)

_____

(Date)

END OF DOCUMENT

**DOCUMENT 00700**

**GENERAL CONDITIONS**

## Prepared By

EJCDC®
ENGINEERS JOINT CONTRACT DOCUMENTS COMMITTEE

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AMERICAN COUNCIL OF ENGINEERING COMPANIES

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## TABLE OF CONTENTS

# DOCUMENT 00700

# GENERAL CONDITIONS

## ARTICLE 1 — DEFINITIONS AND TERMINOLOGY

1.01 Defined Terms

A. Wherever used in the Bidding Requirements or Contract Documents, a term printed with initial capital letters, including the term's singular and plural forms, will have the meaning indicated in the definitions below. In addition to terms specifically defined, terms with initial capital letters in the Contract Documents include references to identified articles and paragraphs, and the titles of other documents or forms.

1. *Addenda*—Written or graphic instruments issued prior to the opening of Bids which clarify, correct, or change the Bidding Requirements or the proposed Contract Documents.
2. *Agreement*—The written instrument, executed by Owner and Contractor, that sets forth the Contract Price and Contract Times, identifies the parties and the Engineer, and designates the specific items that are Contract Documents.
3. *Application for Payment*—The document prepared by Contractor, in a form acceptable to Engineer, to request progress or final payments, and which is to be accompanied by such supporting documentation as is required by the Contract Documents.
4. *Bid*—The offer of a Bidder submitted on the prescribed form setting forth the prices for the Work to be performed.
5. *Bidder*—An individual or entity that submits a Bid to Owner.
6. *Bidding Documents*—The Bidding Requirements, the proposed Contract Documents, and all Addenda.
7. *Bidding Requirements*—The Advertisement or invitation to bid, Instructions to Bidders, Bid Bond or other Bid security, if any, the Bid Form, and the Bid with any attachments.
8. *Change Order*—A document which is signed by Contractor and Owner and authorizes an addition, deletion, or revision in the Work or an adjustment in the Contract Price or the Contract Times, or other revision to the Contract, issued on or after the Effective Date of the Contract.
9. *Change Proposal*—A written request by Contractor, duly submitted in compliance with the procedural requirements set forth herein, seeking an adjustment in Contract Price or Contract Times; contesting an initial decision by Engineer concerning the requirements of the Contract Documents or the acceptability of Work under the Contract Documents; challenging a set-off against payments due; or seeking other relief with respect to the terms of the Contract.
10. *Claim*
    a. A demand or assertion by Owner directly to Contractor, duly submitted in compliance with the procedural requirements set forth herein, seeking an adjustment of Contract Price or Contract Times; contesting an initial decision by Engineer concerning the requirements of the Contract Documents or the acceptability of Work under the Contract Documents; contesting Engineer's decision regarding a Change Proposal; seeking resolution of a contractual issue that Engineer has declined to address; or seeking other relief with respect to the terms of the Contract.

b. A demand or assertion by Contractor directly to Owner, duly submitted in compliance with the procedural requirements set forth herein, contesting Engineer's decision regarding a Change Proposal, or seeking resolution of a contractual issue that Engineer has declined to address.
c. A demand or assertion by Owner or Contractor, duly submitted in compliance with the procedural requirements set forth herein, made pursuant to Paragraph 12.01.A.4, concerning disputes arising after Engineer has issued a recommendation of final payment.
d. A demand for money or services by a third party is not a Claim.

11. *Constituent of Concern*—Asbestos, petroleum, radioactive materials, polychlorinated biphenyls (PCBs), lead-based paint (as defined by the HUD/EPA standard), hazardous waste, and any substance, product, waste, or other material of any nature whatsoever that is or becomes listed, regulated, or addressed pursuant to Laws and Regulations regulating, relating to, or imposing liability or standards of conduct concerning, any hazardous, toxic, or dangerous waste, substance, or material.
12. *Contract*—The entire and integrated written contract between Owner and Contractor concerning the Work.
13. *Contract Documents*—Those items so designated in the Agreement, and which together comprise the Contract.
14. *Contract Price*—The money that Owner has agreed to pay Contractor for completion of the Work in accordance with the Contract Documents.
15. *Contract Times*—The number of days or the dates by which Contractor shall: (a) achieve Milestones, if any; (b) achieve Substantial Completion; and (c) complete the Work.
16. *Contractor*—The individual or entity with which Owner has contracted for performance of the Work.
17. *Cost of the Work*—See Paragraph 13.01 for definition.
18. *Drawings*—The part of the Contract that graphically shows the scope, extent, and character of the Work to be performed by Contractor.
19. *Effective Date of the Contract*—The date, indicated in the Agreement, on which the Contract becomes effective.
20. *Electronic Document*—Any Project-related correspondence, attachments to correspondence, data, documents, drawings, information, or graphics, including but not limited to Shop Drawings and other Submittals, that are in an electronic or digital format.
21. *Electronic Means*—Electronic mail (email), upload/download from a secure Project website, or other communications methods that allow: (a) the transmission or communication of Electronic Documents; (b) the documentation of transmissions, including sending and receipt; (c) printing of the transmitted Electronic Document by the recipient; (d) the storage and archiving of the Electronic Document by sender and recipient; and (e) the use by recipient of the Electronic Document for purposes permitted by this Contract. Electronic Means does not include the use of text messaging, or of Facebook, Twitter, Instagram, or similar social media services for transmission of Electronic Documents.
22. *Engineer*—The individual or entity named as such in the Agreement.
23. *Field Order*—A written order issued by Engineer which requires minor changes in the Work but does not change the Contract Price or the Contract Times.

24. *Hazardous Environmental Condition*—The presence at the Site of Constituents of Concern in such quantities or circumstances that may present a danger to persons or property exposed thereto.
    a. The presence at the Site of materials that are necessary for the execution of the Work, or that are to be incorporated into the Work, and that are controlled and contained pursuant to industry practices, Laws and Regulations, and the requirements of the Contract, is not a Hazardous Environmental Condition.
    b. The presence of Constituents of Concern that are to be removed or remediated as part of the Work is not a Hazardous Environmental Condition.
    c. The presence of Constituents of Concern as part of the routine, anticipated, and obvious working conditions at the Site, is not a Hazardous Environmental Condition.
25. *Laws and Regulations; Laws or Regulations*—Any and all applicable laws, statutes, rules, regulations, ordinances, codes, and binding decrees, resolutions, and orders of any and all governmental bodies, agencies, authorities, and courts having jurisdiction.
26. *Liens*—Charges, security interests, or encumbrances upon Contract-related funds, real property, or personal property.
27. *Milestone*—A principal event in the performance of the Work that the Contract requires Contractor to achieve by an intermediate completion date, or by a time prior to Substantial Completion of all the Work.
28. *Notice of Award*—The written notice by Owner to a Bidder of Owner's acceptance of the Bid.
29. *Notice to Proceed*—A written notice by Owner to Contractor fixing the date on which the Contract Times will commence to run and on which Contractor shall start to perform the Work.
30. *Owner*—The individual or entity with which Contractor has contracted regarding the Work, and which has agreed to pay Contractor for the performance of the Work, pursuant to the terms of the Contract.
31. *Progress Schedule*—A schedule, prepared and maintained by Contractor, describing the sequence and duration of the activities comprising Contractor's plan to accomplish the Work within the Contract Times.
32. *Project*—The total undertaking to be accomplished for Owner by engineers, contractors, and others, including planning, study, design, construction, testing, commissioning, and start-up, and of which the Work to be performed under the Contract Documents is a part.
33. *Resident Project Representative*—The authorized representative of Engineer assigned to assist Engineer at the Site. As used herein, the term Resident Project Representative (RPR) includes any assistants or field staff of Resident Project Representative.
34. *Samples*—Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work and that establish the standards by which such portion of the Work will be judged.
35. *Schedule of Submittals*—A schedule, prepared and maintained by Contractor, of required submittals and the time requirements for Engineer's review of the submittals.
36. *Schedule of Values*—A schedule, prepared and maintained by Contractor, allocating portions of the Contract Price to various portions of the Work and used as the basis for reviewing Contractor's Applications for Payment.

37. *Shop Drawings*—All drawings, diagrams, illustrations, schedules, and other data or information that are specifically prepared or assembled by or for Contractor and submitted by Contractor to illustrate some portion of the Work. Shop Drawings, whether approved or not, are not Drawings and are not Contract Documents.
38. *Site*—Lands or areas indicated in the Contract Documents as being furnished by Owner upon which the Work is to be performed, including rights-of-way and easements, and such other lands or areas furnished by Owner which are designated for the use of Contractor.
39. *Specifications*—The part of the Contract that consists of written requirements for materials, equipment, systems, standards, and workmanship as applied to the Work, and certain administrative requirements and procedural matters applicable to the Work.
40. *Subcontractor*—An individual or entity having a direct contract with Contractor or with any other Subcontractor for the performance of a part of the Work.
41. *Submittal*—A written or graphic document, prepared by or for Contractor, which the Contract Documents require Contractor to submit to Engineer, or that is indicated as a Submittal in the Schedule of Submittals accepted by Engineer. Submittals may include Shop Drawings and Samples; schedules; product data; Owner-delegated designs; sustainable design information; information on special procedures; testing plans; results of tests and evaluations, source quality-control testing and inspections, and field or Site quality-control testing and inspections; warranties and certifications; Suppliers' instructions and reports; records of delivery of spare parts and tools; operations and maintenance data; Project photographic documentation; record documents; and other such documents required by the Contract Documents. Submittals, whether or not approved or accepted by Engineer, are not Contract Documents. Change Proposals, Change Orders, Claims, notices, Applications for Payment, and requests for interpretation or clarification are not Submittals.
42. *Substantial Completion*—The time at which the Work (or a specified part thereof) has progressed to the point where, in the opinion of Engineer, the Work (or a specified part thereof) is sufficiently complete, in accordance with the Contract Documents, so that the Work (or a specified part thereof) can be utilized for the purposes for which it is intended. The terms "substantially complete" and "substantially completed" as applied to all or part of the Work refer to Substantial Completion of such Work.
43. *Successful Bidder*—The Bidder to which the Owner makes an award of contract.
44. *Supplementary Conditions*—The part of the Contract that amends or supplements these General Conditions.
45. *Supplier*—A manufacturer, fabricator, supplier, distributor, or vendor having a direct contract with Contractor or with any Subcontractor to furnish materials or equipment to be incorporated in the Work by Contractor or a Subcontractor.
46. *Technical Data*
    a. Those items expressly identified as Technical Data in the Supplementary Conditions, with respect to either (1) existing subsurface conditions at or adjacent to the Site, or existing physical conditions at or adjacent to the Site including existing surface or subsurface structures (except Underground Facilities) or (2) Hazardous Environmental Conditions at the Site.

b. If no such express identifications of Technical Data have been made with respect to conditions at the Site, then Technical Data is defined, with respect to conditions at the Site under Paragraphs 5.03, 5.04, and 5.06, as the data contained in boring logs, recorded measurements of subsurface water levels, assessments of the condition of subsurface facilities, laboratory test results, and other factual, objective information regarding conditions at the Site that are set forth in any geotechnical, environmental, or other Site or facilities conditions report prepared for the Project and made available to Contractor.
c. Information and data regarding the presence or location of Underground Facilities are not intended to be categorized, identified, or defined as Technical Data, and instead Underground Facilities are shown or indicated on the Drawings.

47. *Underground Facilities*—All active or not-in-service underground lines, pipelines, conduits, ducts, encasements, cables, wires, manholes, vaults, tanks, tunnels, or other such facilities or systems at the Site, including but not limited to those facilities or systems that produce, transmit, distribute, or convey telephone or other communications, cable television, fiber optic transmissions, power, electricity, light, heat, gases, oil, crude oil products, liquid petroleum products, water, steam, waste, wastewater, storm water, other liquids or chemicals, or traffic or other control systems. An abandoned facility or system is not an Underground Facility.
48. *Unit Price Work*—Work to be paid for on the basis of unit prices.
49. *Work*—The entire construction or the various separately identifiable parts thereof required to be provided under the Contract Documents. Work includes and is the result of performing or providing all labor, services, and documentation necessary to produce such construction; furnishing, installing, and incorporating all materials and equipment into such construction; and may include related services such as testing, start-up, and commissioning, all as required by the Contract Documents.
50. *Work Change Directive*—A written directive to Contractor issued on or after the Effective Date of the Contract, signed by Owner and recommended by Engineer, ordering an addition, deletion, or revision in the Work.

1.02 Terminology

A. The words and terms discussed in Paragraphs 1.02.B, C, D, and E are not defined terms that require initial capital letters, but, when used in the Bidding Requirements or Contract Documents, have the indicated meaning.

B. *Intent of Certain Terms or Adjectives*: The Contract Documents include the terms “as allowed,” “as approved,” “as ordered,” “as directed” or terms of like effect or import to authorize an exercise of professional judgment by Engineer. In addition, the adjectives “reasonable,” “suitable,” “acceptable,” “proper,” “satisfactory,” or adjectives of like effect or import are used to describe an action or determination of Engineer as to the Work. It is intended that such exercise of professional judgment, action, or determination will be solely to evaluate, in general, the Work for compliance with the information in the Contract Documents and with the design concept of the Project as a functioning whole as shown or indicated in the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective is not intended to and shall not be effective to assign to Engineer any duty or authority to supervise or direct the performance of the Work, or

any duty or authority to undertake responsibility contrary to the provisions of Article 10 or any other provision of the Contract Documents.

C. *Day*: The word "day" means a calendar day of 24 hours measured from midnight to the next midnight.

D. *Defective*: The word "defective," when modifying the word "Work," refers to Work that is unsatisfactory, faulty, or deficient in that it:
   1. does not conform to the Contract Documents;
   2. does not meet the requirements of any applicable inspection, reference standard, test, or approval referred to in the Contract Documents; or
   3. has been damaged prior to Engineer's recommendation of final payment (unless responsibility for the protection thereof has been assumed by Owner at Substantial Completion in accordance with Paragraph 15.03 or Paragraph 15.04).

E. *Furnish, Install, Perform, Provide*
   1. The word "furnish," when used in connection with services, materials, or equipment, means to supply and deliver said services, materials, or equipment to the Site (or some other specified location) ready for use or installation and in usable or operable condition.
   2. The word "install," when used in connection with services, materials, or equipment, means to put into use or place in final position said services, materials, or equipment complete and ready for intended use.
   3. The words "perform" or "provide," when used in connection with services, materials, or equipment, means to furnish and install said services, materials, or equipment complete and ready for intended use.
   4. If the Contract Documents establish an obligation of Contractor with respect to specific services, materials, or equipment, but do not expressly use any of the four words "furnish," "install," "perform," or "provide," then Contractor shall furnish and install said services, materials, or equipment complete and ready for intended use.

F. *Contract Price or Contract Times*: References to a change in "Contract Price or Contract Times" or "Contract Times or Contract Price" or similar, indicate that such change applies to (1) Contract Price, (2) Contract Times, or (3) both Contract Price and Contract Times, as warranted, even if the term "or both" is not expressed.

G. Unless stated otherwise in the Contract Documents, words or phrases that have a well-known technical or construction industry or trade meaning are used in the Contract Documents in accordance with such recognized meaning.

## ARTICLE 2 — PRELIMINARY MATTERS

2.01 Delivery of Performance and Payment Bonds; Evidence of Insurance

A. *Performance and Payment Bonds*: When Contractor delivers the signed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner the performance bond and payment bond (if the Contract requires Contractor to furnish such bonds).

B. *Evidence of Contractor's Insurance*: When Contractor delivers the signed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner, with copies to each additional insured (as identified in the Contract), the certificates, endorsements, and other evidence of insurance required to be provided by

Contractor in accordance with Article 6, except to the extent the Supplementary Conditions expressly establish other dates for delivery of specific insurance policies.

C. *Evidence of Owner's Insurance*: After receipt of the signed counterparts of the Agreement and all required bonds and insurance documentation, Owner shall promptly deliver to Contractor, with copies to each additional insured (as identified in the Contract), the certificates and other evidence of insurance required to be provided by Owner under Article 6.

2.02 Copies of Documents

A. Owner shall furnish to Contractor four printed copies of the Contract (including one fully signed *counterpart* of the Agreement), and one copy in electronic portable document format (PDF). Additional printed copies will be furnished upon request at the cost of reproduction.

B. Owner shall maintain and safeguard at least one original printed record version of the Contract, including Drawings and Specifications signed and sealed by Engineer and other design professionals. Owner shall make such original printed record version of the Contract available to Contractor for review. Owner may delegate the responsibilities under this provision to Engineer.

2.03 Before Starting Construction

A. *Preliminary Schedules*: Within 10 days after the Effective Date of the Contract (or as otherwise required by the Contract Documents), Contractor shall submit to Engineer for timely review:
   1. a preliminary Progress Schedule indicating the times (numbers of days or dates) for starting and completing the various stages of the Work, including any Milestones specified in the Contract;
   2. a preliminary Schedule of Submittals; and
   3. a preliminary Schedule of Values for all of the Work which includes quantities and prices of items which when added together equal the Contract Price and subdivides the Work into component parts in sufficient detail to serve as the basis for progress payments during performance of the Work. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work.

2.04 Preconstruction Conference; Designation of Authorized Representatives

A. Before any *Work* at the Site is started, a conference attended by Owner, Contractor, Engineer, and others as appropriate will be held to establish a working understanding among the parties as to the Work, and to discuss the schedules referred to in Paragraph 2.03.A, procedures for handling Shop Drawings, Samples, and other Submittals, processing Applications for Payment, electronic or digital transmittals, and maintaining required records.

B. At this conference Owner and Contractor each shall designate, in writing, a specific individual to act as its authorized representative with respect to the services and responsibilities under the Contract. Such individuals shall have the authority to transmit and receive information, render decisions relative to the Contract, and otherwise act on behalf of each respective party.

2.05 Acceptance of Schedules

A. At least 10 days before submission of the first Application for Payment a conference, attended by Contractor, Engineer, and others as appropriate, will be

held to review the schedules submitted in accordance with Paragraph 2.03.A. No progress payment will be made to Contractor until acceptable schedules are submitted to Engineer.

1. The Progress Schedule will be acceptable to Engineer if it provides an orderly progression of the Work to completion within the Contract Times. Such acceptance will not impose on Engineer responsibility for the Progress Schedule, for sequencing, scheduling, or progress of the Work, nor interfere with or relieve Contractor from Contractor's full responsibility therefor.
2. Contractor's Schedule of Submittals will be acceptable to Engineer if it provides a workable arrangement for reviewing and processing the required submittals.
3. Contractor's Schedule of Values will be acceptable to Engineer as to form and substance if it provides a reasonable allocation of the Contract Price to the component parts of the Work.
4. If a schedule is not acceptable, Contractor will have an additional 10 days to revise and resubmit the schedule.

2.06 Electronic Transmittals

A. Except as otherwise stated elsewhere in the Contract, the Owner, Engineer, and Contractor may send, and shall accept, Electronic Documents transmitted by Electronic Means.

B. If the Contract does not establish protocols for Electronic Means, then Owner, Engineer, and Contractor shall jointly develop such protocols.

C. Subject to any governing protocols for Electronic Means, when transmitting Electronic Documents by Electronic Means, the transmitting party makes no representations as to long-term compatibility, usability, or readability of the Electronic Documents resulting from the recipient's use of software application packages, operating systems, or computer hardware differing from those used in the drafting or transmittal of the Electronic Documents.

## ARTICLE 3 — CONTRACT DOCUMENTS: INTENT, REQUIREMENTS, REUSE

3.01 Intent

A. The Contract Documents are complementary; what is required by one Contract Document is as binding as if required by all.

B. It is the intent of the Contract Documents to describe a functionally complete Project (or part thereof) to be constructed in accordance with the Contract Documents.

C. Unless otherwise stated in the Contract Documents, if there is a discrepancy between the electronic versions of the Contract Documents (including any printed copies derived from such electronic versions) and the printed record version, the printed record version will govern.

D. The Contract supersedes prior negotiations, representations, and agreements, whether written or oral.

E. Engineer will issue clarifications and interpretations of the Contract Documents as provided herein.

F. Any provision or part of the Contract Documents held to be void or unenforceable under any Law or Regulation will be deemed stricken, and all remaining provisions will continue to be valid and binding upon Owner and Contractor, which agree that the Contract Documents will be reformed to replace such stricken provision or part

thereof with a valid and enforceable provision that comes as close as possible to expressing the intention of the stricken provision.

G. Nothing in the Contract Documents creates:
   1. any contractual relationship between Owner or Engineer and any Subcontractor, Supplier, or other individual or entity performing or furnishing any of the Work, for the benefit of such Subcontractor, Supplier, or other individual or entity; or
   2. any obligation on the part of Owner or Engineer to pay or to see to the payment of any money due any such Subcontractor, Supplier, or other individual or entity, except as may otherwise be required by Laws and Regulations.

3.02 Reference Standards

A. *Standards Specifications, Codes, Laws and Regulations*
   1. Reference in the Contract Documents to standard specifications, manuals, reference standards, or codes of any technical society, organization, or association, or to Laws or Regulations, whether such reference be specific or by implication, means the standard specification, manual, reference standard, code, or Laws or Regulations in effect at the time of opening of Bids (or on the Effective Date of the Contract if there were no Bids), except as may be otherwise specifically stated in the Contract Documents.
   2. No provision of any such standard specification, manual, reference standard, or code, and no instruction of a Supplier, will be effective to change the duties or responsibilities of Owner, Contractor, or Engineer from those set forth in the part of the Contract Documents prepared by or for Engineer. No such provision or instruction shall be effective to assign to Owner or Engineer any duty or authority to supervise or direct the performance of the Work, or any duty or authority to undertake responsibility inconsistent with the provisions of the part of the Contract Documents prepared by or for Engineer.

3.03 Reporting and Resolving Discrepancies

A. *Reporting Discrepancies*
   1. *Contractor's Verification of Figures and Field Measurements*: Before undertaking each part of the Work, Contractor shall carefully study the Contract Documents, and check and verify pertinent figures and dimensions therein, particularly with respect to applicable field measurements. Contractor shall promptly report in writing to Engineer any conflict, error, ambiguity, or discrepancy that Contractor discovers, or has actual knowledge of, and shall not proceed with any Work affected thereby until the conflict, error, ambiguity, or discrepancy is resolved by a clarification or interpretation by Engineer, or by an amendment or supplement to the Contract issued pursuant to Paragraph 11.01.
   2. *Contractor's Review of Contract Documents*: If, before or during the performance of the Work, Contractor discovers any conflict, error, ambiguity, or discrepancy within the Contract Documents, or between the Contract Documents and (a) any applicable Law or Regulation, (b) actual field conditions, (c) any standard specification, manual, reference standard, or code, or (d) any instruction of any Supplier, then Contractor shall promptly report it to Engineer in writing. Contractor shall not proceed with the Work affected thereby (except in an emergency as required by Paragraph 7.15) until the conflict, error, ambiguity, or discrepancy is resolved, by a clarification or interpretation by

Engineer, or by an amendment or supplement to the Contract issued pursuant to Paragraph 11.01.

3. Contractor shall not be liable to Owner or Engineer for failure to report any conflict, error, ambiguity, or discrepancy in the Contract Documents unless Contractor had actual knowledge thereof.

B. *Resolving Discrepancies*

1. Except as may be otherwise specifically stated in the Contract Documents, the provisions of the part of the Contract Documents prepared by or for Engineer take precedence in resolving any conflict, error, ambiguity, or discrepancy between such provisions of the Contract Documents and:
   a. the provisions of any standard specification, manual, reference standard, or code, or the instruction of any Supplier (whether or not specifically incorporated by reference as a Contract Document); or
   b. the provisions of any Laws or Regulations applicable to the performance of the Work (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

3.04 Requirements of the Contract Documents

A. During the performance of the Work and until final payment, Contractor and Owner shall submit to the Engineer in writing all matters in question concerning the requirements of the Contract Documents (sometimes referred to as requests for information or interpretation—RFIs), or relating to the acceptability of the Work under the Contract Documents, as soon as possible after such matters arise. Engineer will be the initial interpreter of the requirements of the Contract Documents, and judge of the acceptability of the Work.

B. Engineer will, with reasonable promptness, render a written clarification, interpretation, or decision on the issue submitted, or initiate an amendment or supplement to the Contract Documents. Engineer's written clarification, interpretation, or decision will be final and binding on Contractor, unless it appeals by submitting a Change Proposal, and on Owner, unless it appeals by filing a Claim.

C. If a submitted matter in question concerns terms and conditions of the Contract Documents that do not involve (1) the performance or acceptability of the Work under the Contract Documents, (2) the design (as set forth in the Drawings, Specifications, or otherwise), or (3) other engineering or technical matters, then Engineer will promptly notify Owner and Contractor in writing that Engineer is unable to provide a decision or interpretation. If Owner and Contractor are unable to agree on resolution of such a matter in question, either party may pursue resolution as provided in Article 12.

3.05 Reuse of Documents

A. Contractor and its Subcontractors and Suppliers shall not:

1. have or acquire any title to or ownership rights in any of the Drawings, Specifications, or other documents (or copies of any thereof) prepared by or bearing the seal of Engineer or its consultants, including electronic media versions, or reuse any such Drawings, Specifications, other documents, or copies thereof on extensions of the Project or any other project without written consent of Owner and Engineer and specific written verification or adaptation by Engineer; or

2. have or acquire any title or ownership rights in any other Contract Documents, reuse any such Contract Documents for any purpose without Owner's express written consent, or violate any copyrights pertaining to such Contract Documents.

B. The prohibitions of this Paragraph 3.05 will survive final payment, or termination of the Contract. Nothing herein precludes Contractor from retaining copies of the Contract Documents for record purposes.

## ARTICLE 4 — COMMENCEMENT AND PROGRESS OF THE WORK

4.01 Commencement of Contract Times; Notice to Proceed

A. The Contract Times will commence to run on the 30th day after the Effective Date of the Contract or, if a Notice to Proceed is given, on the day indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within 30 days after the Effective Date of the Contract. In no event will the Contract Times commence to run later than the 60th day after the day of Bid opening or the 30th day after the Effective Date of the Contract, whichever date is earlier.

4.02 Starting the Work

A. Contractor shall start to perform the Work on the date when the Contract Times commence to run. No Work may be done at the Site prior to such date.

4.03 Reference Points

A. Owner shall provide engineering surveys to establish reference points for construction which in Engineer's judgment are necessary to enable Contractor to proceed with the Work. Contractor shall be responsible for laying out the Work, shall protect and preserve the established reference points and property monuments, and shall make no changes or relocations without the prior written approval of Owner. Contractor shall report to Engineer whenever any reference point or property monument is lost or destroyed or requires relocation because of necessary changes in grades or locations, and shall be responsible for the accurate replacement or relocation of such reference points or property monuments by professionally qualified personnel.

4.04 Progress Schedule

A. Contractor shall adhere to the Progress Schedule established in accordance with Paragraph 2.05 as it may be adjusted from time to time as provided below.
   1. Contractor shall submit to Engineer for acceptance (to the extent indicated in Paragraph 2.05) proposed adjustments in the Progress Schedule that will not result in changing the Contract Times.
   2. Proposed adjustments in the Progress Schedule that will change the Contract Times must be submitted in accordance with the requirements of Article 11.

B. Contractor shall carry on the Work and adhere to the Progress Schedule during all disputes or disagreements with Owner. No Work will be delayed or postponed pending resolution of any disputes or disagreements, or during any appeal process, except as permitted by Paragraph 16.04, or as Owner and Contractor may otherwise agree in writing.

4.05 Delays in Contractor's Progress

A. If Owner, Engineer, or anyone for whom Owner is responsible, delays, disrupts, or interferes with the performance or progress of the Work, then Contractor shall be entitled to an equitable adjustment in Contract Price or Contract Times.

B. Contractor shall not be entitled to an adjustment in Contract Price or Contract Times for delay, disruption, or interference caused by or within the control of Contractor. Delay, disruption, and interference attributable to and within the control of a Subcontractor or Supplier shall be deemed to be within the control of Contractor.

C. If Contractor's performance or progress is delayed, disrupted, or interfered with by unanticipated causes not the fault of and beyond the control of Owner, Contractor, and those for which they are responsible, then Contractor shall be entitled to an equitable adjustment in Contract Times. Such an adjustment will be Contractor's sole and exclusive remedy for the delays, disruption, and interference described in this paragraph. Causes of delay, disruption, or interference that may give rise to an adjustment in Contract Times under this paragraph include but are not limited to the following:
   1. Severe and unavoidable natural catastrophes such as fires, floods, epidemics, and earthquakes;
   2. Abnormal weather conditions;
   3. Acts or failures to act of third-party utility owners or other third-party entities (other than those third-party utility owners or other third-party entities performing other work at or adjacent to the Site as arranged by or under contract with Owner, as contemplated in Article 8); and
   4. Acts of war or terrorism.

D. Contractor's entitlement to an adjustment of Contract Times or Contract Price is limited as follows:
   1. Contractor's entitlement to an adjustment of the Contract Times is conditioned on the delay, disruption, or interference adversely affecting an activity on the critical path to completion of the Work, as of the time of the delay, disruption, or interference.
   2. Contractor shall not be entitled to an adjustment in Contract Price for any delay, disruption, or interference if such delay is concurrent with a delay, disruption, or interference caused by or within the control of Contractor. Such a concurrent delay by Contractor shall not preclude an adjustment of Contract Times to which Contractor is otherwise entitled.
   3. Adjustments of Contract Times or Contract Price are subject to the provisions of Article 11.

E. Each Contractor request or Change Proposal seeking an increase in Contract Times or Contract Price must be supplemented by supporting data that sets forth in detail the following:
   1. The circumstances that form the basis for the requested adjustment;
   2. The date upon which each cause of delay, disruption, or interference began to affect the progress of the Work;
   3. The date upon which each cause of delay, disruption, or interference ceased to affect the progress of the Work;
   4. The number of days' increase in Contract Times claimed as a consequence of each such cause of delay, disruption, or interference; and

5. The impact on Contract Price, in accordance with the provisions of Paragraph 11.07.

Contractor shall also furnish such additional supporting documentation as Owner or Engineer may require including, where appropriate, a revised progress schedule indicating all the activities affected by the delay, disruption, or interference, and an explanation of the effect of the delay, disruption, or interference on the critical path to completion of the Work.

F. Delays, disruption, and interference to the performance or progress of the Work resulting from the existence of a differing subsurface or physical condition, an Underground Facility that was not shown or indicated by the Contract Documents, or not shown or indicated with reasonable accuracy, and those resulting from Hazardous Environmental Conditions, are governed by Article 5, together with the provisions of Paragraphs 4.05.D and 4.05.E.

G. Paragraph 8.03 addresses delays, disruption, and interference to the performance or progress of the Work resulting from the performance of certain other work at or adjacent to the Site.

## ARTICLE 5 — SITE; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS

5.01 Availability of Lands

A. Owner shall furnish the Site. Owner shall notify Contractor in writing of any encumbrances or restrictions not of general application but specifically related to use of the Site with which Contractor must comply in performing the Work.

B. Upon reasonable written request, Owner shall furnish Contractor with a current statement of record legal title and legal description of the lands upon which permanent improvements are to be made and Owner's interest therein as necessary for giving notice of or filing a mechanic's or construction lien against such lands in accordance with applicable Laws and Regulations.

C. Contractor shall provide for all additional lands and access thereto that may be required for temporary construction facilities or storage of materials and equipment.

5.02 Use of Site and Other Areas

A. *Limitation on Use of Site and Other Areas*

1. Contractor shall confine construction equipment, temporary construction facilities, the storage of materials and equipment, and the operations of workers to the Site, adjacent areas that Contractor has arranged to use through construction easements or otherwise, and other adjacent areas permitted by Laws and Regulations, and shall not unreasonably encumber the Site and such other adjacent areas with construction equipment or other materials or equipment. Contractor shall assume full responsibility for (a) damage to the Site; (b) damage to any such other adjacent areas used for Contractor's operations; (c) damage to any other adjacent land or areas, or to improvements, structures, utilities, or similar facilities located at such adjacent lands or areas; and (d) for injuries and losses sustained by the owners or occupants of any such land or areas; provided that such damage or injuries result from the performance of the Work or from other actions or conduct of the Contractor or those for which Contractor is responsible.

2. If a damage or injury claim is made by the owner or occupant of any such land or area because of the performance of the Work, or because of other actions or conduct of the Contractor or those for which Contractor is responsible, Contractor shall (a) take immediate corrective or remedial action as required by Paragraph 7.13, or otherwise; (b) promptly attempt to settle the claim as to all parties through negotiations with such owner or occupant, or otherwise resolve the claim by arbitration or other dispute resolution proceeding, or in a court of competent jurisdiction; and (c) to the fullest extent permitted by Laws and Regulations, indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, from and against any such claim, and against all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any claim or action, legal or equitable, brought by any such owner or occupant against Owner, Engineer, or any other party indemnified hereunder to the extent caused directly or indirectly, in whole or in part by, or based upon, Contractor's performance of the Work, or because of other actions or conduct of the Contractor or those for which Contractor is responsible.

B. *Removal of Debris During Performance of the Work*: During the progress of the Work the Contractor shall keep the Site and other adjacent areas free from accumulations of waste materials, rubbish, and other debris. Removal and disposal of such waste materials, rubbish, and other debris will conform to applicable Laws and Regulations.

C. *Cleaning*: Prior to Substantial Completion of the Work Contractor shall clean the Site and the Work and make it ready for utilization by Owner. At the completion of the Work Contractor shall remove from the Site and adjacent areas all tools, appliances, construction equipment and machinery, and surplus materials and shall restore to original condition all property not designated for alteration by the Contract Documents.

D. *Loading of Structures*: Contractor shall not load nor permit any part of any structure to be loaded in any manner that will endanger the structure, nor shall Contractor subject any part of the Work or adjacent structures or land to stresses or pressures that will endanger them.

5.03 Subsurface and Physical Conditions

A. *Reports and Drawings*: The Supplementary Conditions identify:
1. Those reports of explorations and tests of subsurface conditions at or adjacent to the Site that contain Technical Data;
2. Those drawings of existing physical conditions at or adjacent to the Site, including those drawings depicting existing surface or subsurface structures at or adjacent to the Site (except Underground Facilities), that contain Technical Data; and
3. Technical Data contained in such reports and drawings.

B. *Underground Facilities*: Underground Facilities are shown or indicated on the Drawings, pursuant to Paragraph 5.05, and not in the drawings referred to in Paragraph 5.03.A. Information and data regarding the presence or location of Underground Facilities are not intended to be categorized, identified, or defined as Technical Data.

C. *Reliance by Contractor on Technical Data*: Contractor may rely upon the accuracy of the Technical Data expressly identified in the Supplementary Conditions with respect to such reports and drawings, but such reports and drawings are not Contract Documents. If no such express identification has been made, then Contractor may rely upon the accuracy of the Technical Data as defined in Paragraph 1.01.A.46.b.

D. *Limitations of Other Data and Documents*: Except for such reliance on Technical Data, Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, with respect to:
   1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences, and procedures of construction to be employed by Contractor, and safety precautions and programs incident thereto;
   2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings;
   3. the contents of other Site-related documents made available to Contractor, such as record drawings from other projects at or adjacent to the Site, or Owner's archival documents concerning the Site; or
   4. any Contractor interpretation of or conclusion drawn from any Technical Data or any such other data, interpretations, opinions, or information.

5.04 Differing Subsurface or Physical Conditions

A. *Notice by Contractor*: If Contractor believes that any subsurface or physical condition that is uncovered or revealed at the Site:
   1. is of such a nature as to establish that any Technical Data on which Contractor is entitled to rely as provided in Paragraph 5.03 is materially inaccurate;
   2. is of such a nature as to require a change in the Drawings or Specifications;
   3. differs materially from that shown or indicated in the Contract Documents; or
   4. is of an unusual nature, and differs materially from conditions ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract Documents;

   then Contractor shall, promptly after becoming aware thereof and before further disturbing the subsurface or physical conditions or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15), notify Owner and Engineer in writing about such condition. Contractor shall not further disturb such condition or perform any Work in connection therewith (except with respect to an emergency) until receipt of a written statement permitting Contractor to do so.

B. *Engineer's Review*: After receipt of written notice as required by the preceding paragraph, Engineer will promptly review the subsurface or physical condition in question; determine whether it is necessary for Owner to obtain additional exploration or tests with respect to the condition; conclude whether the condition falls within any one or more of the differing site condition categories in Paragraph 5.04.A; obtain any pertinent cost or schedule information from Contractor; prepare recommendations to Owner regarding the Contractor's resumption of Work in connection with the subsurface or physical condition in question and the need for any change in the Drawings or Specifications; and advise Owner in writing of Engineer's findings, conclusions, and recommendations.

C. *Owner's Statement to Contractor Regarding Site Condition*: After receipt of Engineer's written findings, conclusions, and recommendations, Owner shall issue a written statement to Contractor (with a copy to Engineer) regarding the subsurface or physical condition in question, addressing the resumption of Work in connection with such condition, indicating whether any change in the Drawings or Specifications will be made, and adopting or rejecting Engineer's written findings, conclusions, and recommendations, in whole or in part.

D. *Early Resumption of Work*: If at any time Engineer determines that Work in connection with the subsurface or physical condition in question may resume prior to completion of Engineer's review or Owner's issuance of its statement to Contractor, because the condition in question has been adequately documented, and analyzed on a preliminary basis, then the Engineer may at its discretion instruct Contractor to resume such Work.

E. *Possible Price and Times Adjustments*
   1. Contractor shall be entitled to an equitable adjustment in Contract Price or Contract Times, to the extent that the existence of a differing subsurface or physical condition, or any related delay, disruption, or interference, causes an increase or decrease in Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:
      a. Such condition must fall within any one or more of the categories described in Paragraph 5.04.A;
      b. With respect to Work that is paid for on a unit price basis, any adjustment in Contract Price will be subject to the provisions of Paragraph 13.03; and,
      c. Contractor's entitlement to an adjustment of the Contract Times is subject to the provisions of Paragraphs 4.05.D and 4.05.E.
   2. Contractor shall not be entitled to any adjustment in the Contract Price or Contract Times with respect to a subsurface or physical condition if:
      a. Contractor knew of the existence of such condition at the time Contractor made a commitment to Owner with respect to Contract Price and Contract Times by the submission of a Bid or becoming bound under a negotiated contract, or otherwise;
      b. The existence of such condition reasonably could have been discovered or revealed as a result of any examination, investigation, exploration, test, or study of the Site and contiguous areas expressly required by the Bidding Requirements or Contract Documents to be conducted by or for Contractor prior to Contractor's making such commitment; or
      c. Contractor failed to give the written notice required by Paragraph 5.04.A.
   3. If Owner and Contractor agree regarding Contractor's entitlement to and the amount or extent of any adjustment in the Contract Price or Contract Times, then any such adjustment will be set forth in a Change Order.
   4. Contractor may submit a Change Proposal regarding its entitlement to or the amount or extent of any adjustment in the Contract Price or Contract Times, no later than 30 days after Owner's issuance of the Owner's written statement to Contractor regarding the subsurface or physical condition in question.

F. *Underground Facilities; Hazardous Environmental Conditions*: Paragraph 5.05 governs rights and responsibilities regarding the presence or location of Underground Facilities. Paragraph 5.06 governs rights and responsibilities regarding Hazardous Environmental Conditions. The provisions of Paragraphs 5.03 and 5.04

are not applicable to the presence or location of Underground Facilities, or to Hazardous Environmental Conditions.

5.05 Underground Facilities

A. *Contractor's Responsibilities*: Unless it is otherwise expressly provided in the Supplementary Conditions, the cost of all of the following are included in the Contract Price, and Contractor shall have full responsibility for:
   1. reviewing and checking all information and data regarding existing Underground Facilities at the Site;
   2. complying with applicable state and local utility damage prevention Laws and Regulations;
   3. verifying the actual location of those Underground Facilities shown or indicated in the Contract Documents as being within the area affected by the Work, by exposing such Underground Facilities during the course of construction;
   4. coordination of the Work with the owners (including Owner) of such Underground Facilities, during construction; and
   5. the safety and protection of all existing Underground Facilities at the Site, and repairing any damage thereto resulting from the Work.

B. *Notice by Contractor*: If Contractor believes that an Underground Facility that is uncovered or revealed at the Site was not shown or indicated on the Drawings, or was not shown or indicated on the Drawings with reasonable accuracy, then Contractor shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15), notify Owner and Engineer in writing regarding such Underground Facility.

C. *Engineer's Review*: Engineer will:
   1. promptly review the Underground Facility and conclude whether such Underground Facility was not shown or indicated on the Drawings, or was not shown or indicated with reasonable accuracy;
   2. identify and communicate with the owner of the Underground Facility; prepare recommendations to Owner (and if necessary issue any preliminary instructions to Contractor) regarding the Contractor's resumption of Work in connection with the Underground Facility in question;
   3. obtain any pertinent cost or schedule information from Contractor; determine the extent, if any, to which a change is required in the Drawings or Specifications to reflect and document the consequences of the existence or location of the Underground Facility; and
   4. advise Owner in writing of Engineer's findings, conclusions, and recommendations.

   During such time, Contractor shall be responsible for the safety and protection of such Underground Facility.

D. *Owner's Statement to Contractor Regarding Underground Facility*: After receipt of Engineer's written findings, conclusions, and recommendations, Owner shall issue a written statement to Contractor (with a copy to Engineer) regarding the Underground Facility in question addressing the resumption of Work in connection with such Underground Facility, indicating whether any change in the Drawings or Specifications will be made, and adopting or rejecting Engineer's written findings, conclusions, and recommendations in whole or in part.

E. *Early Resumption of Work*: If at any time Engineer determines that Work in connection with the Underground Facility may resume prior to completion of Engineer's review or Owner's issuance of its statement to Contractor, because the Underground Facility in question and conditions affected by its presence have been adequately documented, and analyzed on a preliminary basis, then the Engineer may at its discretion instruct Contractor to resume such Work.

F. *Possible Price and Times Adjustments*
   1. Contractor shall be entitled to an equitable adjustment in the Contract Price or Contract Times, to the extent that any existing Underground Facility at the Site that was not shown or indicated on the Drawings, or was not shown or indicated with reasonable accuracy, or any related delay, disruption, or interference, causes an increase or decrease in Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:
      a. With respect to Work that is paid for on a unit price basis, any adjustment in Contract Price will be subject to the provisions of Paragraph 13.03;
      b. Contractor's entitlement to an adjustment of the Contract Times is subject to the provisions of Paragraphs 4.05.D and 4.05.E; and
      c. Contractor gave the notice required in Paragraph 5.05.B.
   2. If Owner and Contractor agree regarding Contractor's entitlement to and the amount or extent of any adjustment in the Contract Price or Contract Times, then any such adjustment will be set forth in a Change Order.
   3. Contractor may submit a Change Proposal regarding its entitlement to or the amount or extent of any adjustment in the Contract Price or Contract Times, no later than 30 days after Owner's issuance of the Owner's written statement to Contractor regarding the Underground Facility in question.
   4. The information and data shown or indicated on the Drawings with respect to existing Underground Facilities at the Site is based on information and data (a) furnished by the owners of such Underground Facilities, or by others, (b) obtained from available records, or (c) gathered in an investigation conducted in accordance with the current edition of ASCE 38, Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, by the American Society of Civil Engineers. If such information or data is incorrect or incomplete, Contractor's remedies are limited to those set forth in this Paragraph 5.05.F.

5.06 Hazardous Environmental Conditions at Site

A. *Reports and Drawings*: The Supplementary Conditions identify:
   1. those reports known to Owner relating to Hazardous Environmental Conditions that have been identified at or adjacent to the Site;
   2. drawings known to Owner relating to Hazardous Environmental Conditions that have been identified at or adjacent to the Site; and
   3. Technical Data contained in such reports and drawings.

B. *Reliance by Contractor on Technical Data Authorized*: Contractor may rely upon the accuracy of the Technical Data expressly identified in the Supplementary Conditions with respect to such reports and drawings, but such reports and drawings are not Contract Documents. If no such express identification has been made, then Contractor may rely on the accuracy of the Technical Data as defined in Paragraph 1.01.A.46.b. Except for such reliance on Technical Data, Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers,

directors, members, partners, employees, agents, consultants, or subcontractors, with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences and procedures of construction to be employed by Contractor, and safety precautions and programs incident thereto;
2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings; or
3. any Contractor interpretation of or conclusion drawn from any Technical Data or any such other data, interpretations, opinions or information.

C. Contractor shall not be responsible for removing or remediating any Hazardous Environmental Condition encountered, uncovered, or revealed at the Site unless such removal or remediation is expressly identified in the Contract Documents to be within the scope of the Work.

D. Contractor shall be responsible for controlling, containing, and duly removing all Constituents of Concern brought to the Site by Contractor, Subcontractors, Suppliers, or anyone else for whom Contractor is responsible, and for any associated costs; and for the costs of removing and remediating any Hazardous Environmental Condition created by the presence of any such Constituents of Concern.

E. If Contractor encounters, uncovers, or reveals a Hazardous Environmental Condition whose removal or remediation is not expressly identified in the Contract Documents as being within the scope of the Work, or if Contractor or anyone for whom Contractor is responsible creates a Hazardous Environmental Condition, then Contractor shall immediately: (1) secure or otherwise isolate such condition; (2) stop all Work in connection with such condition and in any area affected thereby (except in an emergency as required by Paragraph 7.15); and (3) notify Owner and Engineer (and promptly thereafter confirm such notice in writing). Owner shall promptly consult with Engineer concerning the necessity for Owner to retain a qualified expert to evaluate such condition or take corrective action, if any. Promptly after consulting with Engineer, Owner shall take such actions as are necessary to permit Owner to timely obtain required permits and provide Contractor the written notice required by Paragraph 5.06.F. If Contractor or anyone for whom Contractor is responsible created the Hazardous Environmental Condition in question, then Owner may remove and remediate the Hazardous Environmental Condition, and impose a set-off against payments to account for the associated costs.

F. Contractor shall not resume Work in connection with such Hazardous Environmental Condition or in any affected area until after Owner has obtained any required permits related thereto, and delivered written notice to Contractor either (1) specifying that such condition and any affected area is or has been rendered safe for the resumption of Work, or (2) specifying any special conditions under which such Work may be resumed safely.

G. If Owner and Contractor cannot agree as to entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times, as a result of such Work stoppage, such special conditions under which Work is agreed to be resumed by Contractor, or any costs or expenses incurred in response to the Hazardous Environmental Condition, then within 30 days of Owner's written notice regarding the resumption of Work, Contractor may submit a Change Proposal, or

Owner may impose a set-off. Entitlement to any such adjustment is subject to the provisions of Paragraphs 4.05.D, 4.05.E, 11.07, and 11.08.

H. If, after receipt of such written notice, Contractor does not agree to resume such Work based on a reasonable belief it is unsafe, or does not agree to resume such Work under such special conditions, then Owner may order the portion of the Work that is in the area affected by such condition to be deleted from the Work, following the contractual change procedures in Article 11. Owner may have such deleted portion of the Work performed by Owner's own forces or others in accordance with Article 8.

I. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court, arbitration, or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition, provided that such Hazardous Environmental Condition (1) was not shown or indicated in the Drawings, Specifications, or other Contract Documents, identified as Technical Data entitled to limited reliance pursuant to Paragraph 5.06.B, or identified in the Contract Documents to be included within the scope of the Work, and (2) was not created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 5.06.I obligates Owner to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

J. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to the failure to control, contain, or remove a Constituent of Concern brought to the Site by Contractor or by anyone for whom Contractor is responsible, or to a Hazardous Environmental Condition created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 5.06.J obligates Contractor to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

K. The provisions of Paragraphs 5.03, 5.04, and 5.05 do not apply to the presence of Constituents of Concern or to a Hazardous Environmental Condition uncovered or revealed at the Site.

## ARTICLE 6 — BONDS AND INSURANCE

6.01 Performance, Payment, and Other Bonds

A. Contractor shall furnish a performance bond and a payment bond, each in an amount at least equal to the Contract Price, as security for the faithful performance and payment of Contractor's obligations under the Contract. These bonds must remain in effect until one year after the date when final payment becomes due or until completion of the correction period specified in Paragraph 15.08, whichever is later, except as provided otherwise by Laws or Regulations, the terms of a

prescribed bond form, the Supplementary Conditions, or other provisions of the Contract.

B. Contractor shall also furnish such other bonds (if any) as are required by the Supplementary Conditions or other provisions of the Contract.

C. All bonds must be in the form included in the Bidding Documents or otherwise specified by Owner prior to execution of the Contract, except as provided otherwise by Laws or Regulations, and must be issued and signed by a surety named in "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Department Circular 570 (as amended and supplemented) by the Bureau of the Fiscal Service, U.S. Department of the Treasury. A bond signed by an agent or attorney-in-fact must be accompanied by a certified copy of that individual's authority to bind the surety. The evidence of authority must show that it is effective on the date the agent or attorney-in-fact signed the accompanying bond.

D. Contractor shall obtain the required bonds from surety companies that are duly licensed or authorized, in the state or jurisdiction in which the Project is located, to issue bonds in the required amounts.

E. If the surety on a bond furnished by Contractor is declared bankrupt or becomes insolvent, or the surety ceases to meet the requirements above, then Contractor shall promptly notify Owner and Engineer in writing and shall, within 20 days after the event giving rise to such notification, provide another bond and surety, both of which must comply with the bond and surety requirements above.

F. If Contractor has failed to obtain a required bond, Owner may exclude the Contractor from the Site and exercise Owner's termination rights under Article 16.

G. Upon request to Owner from any Subcontractor, Supplier, or other person or entity claiming to have furnished labor, services, materials, or equipment used in the performance of the Work, Owner shall provide a copy of the payment bond to such person or entity.

H. Upon request to Contractor from any Subcontractor, Supplier, or other person or entity claiming to have furnished labor, services, materials, or equipment used in the performance of the Work, Contractor shall provide a copy of the payment bond to such person or entity.

6.02 Insurance—General Provisions

A. Owner and Contractor shall obtain and maintain insurance as required in this article and in the Supplementary Conditions.

B. All insurance required by the Contract to be purchased and maintained by Owner or Contractor shall be obtained from insurance companies that are duly licensed or authorized in the state or jurisdiction in which the Project is located to issue insurance policies for the required limits and coverages. Unless a different standard is indicated in the Supplementary Conditions, all companies that provide insurance policies required under this Contract shall have an A.M. Best rating of A-VII or better.

C. Alternative forms of insurance coverage, including but not limited to self-insurance and "Occupational Accident and Excess Employer's Indemnity Policies," are not sufficient to meet the insurance requirements of this Contract, unless expressly allowed in the Supplementary Conditions.

D. Contractor shall deliver to Owner, with copies to each additional insured identified in the Contract, certificates of insurance and endorsements establishing that Contractor has obtained and is maintaining the policies and coverages required by the Contract. Upon request by Owner or any other insured, Contractor shall also furnish other evidence of such required insurance, including but not limited to copies of policies, documentation of applicable self-insured retentions (if allowed) and deductibles, full disclosure of all relevant exclusions, and evidence of insurance required to be purchased and maintained by Subcontractors or Suppliers. In any documentation furnished under this provision, Contractor, Subcontractors, and Suppliers may block out (redact) (1) any confidential premium or pricing information and (2) any wording specific to a project or jurisdiction other than those applicable to this Contract.

E. Owner shall deliver to Contractor, with copies to each additional insured identified in the Contract, certificates of insurance and endorsements establishing that Owner has obtained and is maintaining the policies and coverages required of Owner by the Contract (if any). Upon request by Contractor or any other insured, Owner shall also provide other evidence of such required insurance (if any), including but not limited to copies of policies, documentation of applicable self-insured retentions (if allowed) and deductibles, and full disclosure of all relevant exclusions. In any documentation furnished under this provision, Owner may block out (redact) (1) any confidential premium or pricing information and (2) any wording specific to a project or jurisdiction other than those relevant to this Contract.

F. Failure of Owner or Contractor to demand such certificates or other evidence of the other party's full compliance with these insurance requirements, or failure of Owner or Contractor to identify a deficiency in compliance from the evidence provided, will not be construed as a waiver of the other party's obligation to obtain and maintain such insurance.

G. In addition to the liability insurance required to be provided by Contractor, the Owner, at Owner's option, may purchase and maintain Owner's own liability insurance. Owner's liability policies, if any, operate separately and independently from policies required to be provided by Contractor, and Contractor cannot rely upon Owner's liability policies for any of Contractor's obligations to the Owner, Engineer, or third parties.

H. Contractor shall require:
   1. Subcontractors to purchase and maintain worker's compensation, commercial general liability, and other insurance that is appropriate for their participation in the Project, and to name as additional insureds Owner and Engineer (and any other individuals or entities identified in the Supplementary Conditions as additional insureds on Contractor's liability policies) on each Subcontractor's commercial general liability insurance policy; and
   2. Suppliers to purchase and maintain insurance that is appropriate for their participation in the Project.

I. If either party does not purchase or maintain the insurance required of such party by the Contract, such party shall notify the other party in writing of such failure to purchase prior to the start of the Work, or of such failure to maintain prior to any change in the required coverage.

J. If Contractor has failed to obtain and maintain required insurance, Contractor's entitlement to enter or remain at the Site will end immediately, and Owner may

impose an appropriate set-off against payment for any associated costs (including but not limited to the cost of purchasing necessary insurance coverage), and exercise Owner's termination rights under Article 16.

K. Without prejudice to any other right or remedy, if a party has failed to obtain required insurance, the other party may elect (but is in no way obligated) to obtain equivalent insurance to protect such other party's interests at the expense of the party who was required to provide such coverage, and the Contract Price will be adjusted accordingly.

L. Owner does not represent that insurance coverage and limits established in this Contract necessarily will be adequate to protect Contractor or Contractor's interests. Contractor is responsible for determining whether such coverage and limits are adequate to protect its interests, and for obtaining and maintaining any additional insurance that Contractor deems necessary.

M. The insurance and insurance limits required herein will not be deemed as a limitation on Contractor's liability, or that of its Subcontractors or Suppliers, under the indemnities granted to Owner and other individuals and entities in the Contract or otherwise.

N. All the policies of insurance required to be purchased and maintained under this Contract will contain a provision or endorsement that the coverage afforded will not be canceled, or renewal refused, until at least 10 days prior written notice has been given to the purchasing policyholder. Within three days of receipt of any such written notice, the purchasing policyholder shall provide a copy of the notice to each other insured and Engineer.

6.03 Contractor's Insurance

A. *Required Insurance*: Contractor shall purchase and maintain Worker's Compensation, Commercial General Liability, and other insurance pursuant to the specific requirements of the Supplementary Conditions.

B. *General Provisions*: The policies of insurance required by this Paragraph 6.03 as supplemented must:

1. include at least the specific coverages required;
2. be written for not less than the limits provided, or those required by Laws or Regulations, whichever is greater;
3. remain in effect at least until the Work is complete (as set forth in Paragraph 15.06.D), and longer if expressly required elsewhere in this Contract, and at all times thereafter when Contractor may be correcting, removing, or replacing defective Work as a warranty or correction obligation, or otherwise, or returning to the Site to conduct other tasks arising from the Contract;
4. apply with respect to the performance of the Work, whether such performance is by Contractor, any Subcontractor or Supplier, or by anyone directly or indirectly employed by any of them to perform any of the Work, or by anyone for whose acts any of them may be liable; and
5. include all necessary endorsements to support the stated requirements.

C. *Additional Insureds*: The Contractor's commercial general liability, automobile liability, employer's liability, umbrella or excess, pollution liability, and unmanned aerial vehicle liability policies, if required by this Contract, must:
   1. include and list as additional insureds Owner and Engineer, and any individuals or entities identified as additional insureds in the Supplementary Conditions;
   2. include coverage for the respective officers, directors, members, partners, employees, and consultants of all such additional insureds;
   3. afford primary coverage to these additional insureds for all claims covered thereby (including as applicable those arising from both ongoing and completed operations);
   4. not seek contribution from insurance maintained by the additional insured; and
   5. as to commercial general liability insurance, apply to additional insureds with respect to liability caused in whole or in part by Contractor's acts or omissions, or the acts and omissions of those working on Contractor's behalf, in the performance of Contractor's operations.

6.04 Builder's Risk and Other Property Insurance

A. *Builder's Risk*: Unless otherwise provided in the Supplementary Conditions, Contractor shall purchase and maintain builder's risk insurance upon the Work on a completed value basis, in the amount of the Work's full insurable replacement cost (subject to such deductible amounts as may be provided in the Supplementary Conditions or required by Laws and Regulations). The specific requirements applicable to the builder's risk insurance are set forth in the Supplementary Conditions.

B. *Property Insurance for Facilities of Owner Where Work Will Occur*: Owner is responsible for obtaining and maintaining property insurance covering each existing structure, building, or facility in which any part of the Work will occur, or to which any part of the Work will attach or be adjoined. Such property insurance will be written on a special perils (all-risk) form, on a replacement cost basis, providing coverage consistent with that required for the builder's risk insurance, and will be maintained until the Work is complete, as set forth in Paragraph 15.06.D.

C. *Property Insurance for Substantially Complete Facilities*: Promptly after Substantial Completion, and before actual occupancy or use of the substantially completed Work, Owner will obtain property insurance for such substantially completed Work, and maintain such property insurance at least until the Work is complete, as set forth in Paragraph 15.06.D. Such property insurance will be written on a special perils (all-risk) form, on a replacement cost basis, and provide coverage consistent with that required for the builder's risk insurance. The builder's risk insurance may terminate upon written confirmation of Owner's procurement of such property insurance.

D. *Partial Occupancy or Use by Owner*: If Owner will occupy or use a portion or portions of the Work prior to Substantial Completion of all the Work, as provided in Paragraph 15.04, then Owner (directly, if it is the purchaser of the builder's risk policy, or through Contractor) will provide advance notice of such occupancy or use to the builder's risk insurer, and obtain an endorsement consenting to the continuation of coverage prior to commencing such partial occupancy or use.

E. *Insurance of Other Property; Additional Insurance*: If the express insurance provisions of the Contract do not require or address the insurance of a property item or interest, then the entity or individual owning such property item will be responsible

for insuring it. If Contractor elects to obtain other special insurance to be included in or supplement the builder's risk or property insurance policies provided under this Paragraph 6.04, it may do so at Contractor's expense.

6.05 Property Losses; Subrogation

A. The builder's risk insurance policy purchased and maintained in accordance with Paragraph 6.04 (or an installation floater policy if authorized by the Supplementary Conditions), will contain provisions to the effect that in the event of payment of any loss or damage the insurer will have no rights of recovery against any insureds thereunder, or against Engineer or its consultants, or their officers, directors, members, partners, employees, agents, consultants, or subcontractors.

1. Owner and Contractor waive all rights against each other and the respective officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, for all losses and damages caused by, arising out of, or resulting from any of the perils, risks, or causes of loss covered by such policies and any other property insurance applicable to the Work; and, in addition, waive all such rights against Engineer, its consultants, all individuals or entities identified in the Supplementary Conditions as builder's risk or installation floater insureds, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, under such policies for losses and damages so caused.
2. None of the above waivers extends to the rights that any party making such waiver may have to the proceeds of insurance held by Owner or Contractor as trustee or fiduciary, or otherwise payable under any policy so issued.

B. Any property insurance policy maintained by Owner covering any loss, damage, or consequential loss to Owner's existing structures, buildings, or facilities in which any part of the Work will occur, or to which any part of the Work will attach or adjoin; to adjacent structures, buildings, or facilities of Owner; or to part or all of the completed or substantially completed Work, during partial occupancy or use pursuant to Paragraph 15.04, after Substantial Completion pursuant to Paragraph 15.03, or after final payment pursuant to Paragraph 15.06, will contain provisions to the effect that in the event of payment of any loss or damage the insurer will have no rights of recovery against any insureds thereunder, or against Contractor, Subcontractors, or Engineer, or the officers, directors, members, partners, employees, agents, consultants, or subcontractors of each and any of them, and that the insured is allowed to waive the insurer's rights of subrogation in a written contract executed prior to the loss, damage, or consequential loss.

1. Owner waives all rights against Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, for all losses and damages caused by, arising out of, or resulting from fire or any of the perils, risks, or causes of loss covered by such policies.

C. The waivers in this Paragraph 6.05 include the waiver of rights due to business interruption, loss of use, or other consequential loss extending beyond direct physical loss or damage to Owner's property or the Work caused by, arising out of, or resulting from fire or other insured peril, risk, or cause of loss.

D. Contractor shall be responsible for assuring that each Subcontract contains provisions whereby the Subcontractor waives all rights against Owner, Contractor, all individuals or entities identified in the Supplementary Conditions as insureds, the

Engineer and its consultants, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, for all losses and damages caused by, arising out of, relating to, or resulting from fire or other peril, risk, or cause of loss covered by builder's risk insurance, installation floater, and any other property insurance applicable to the Work.

6.06 Receipt and Application of Property Insurance Proceeds

A. Any insured loss under the builder's risk and other policies of property insurance required by Paragraph 6.04 will be adjusted and settled with the named insured that purchased the policy. Such named insured shall act as fiduciary for the other insureds, and give notice to such other insureds that adjustment and settlement of a claim is in progress. Any other insured may state its position regarding a claim for insured loss in writing within 15 days after notice of such claim.

B. Proceeds for such insured losses may be made payable by the insurer either jointly to multiple insureds, or to the named insured that purchased the policy in its own right and as fiduciary for other insureds, subject to the requirements of any applicable mortgage clause. A named insured receiving insurance proceeds under the builder's risk and other policies of insurance required by Paragraph 6.04 shall maintain such proceeds in a segregated account, and distribute such proceeds in accordance with such agreement as the parties in interest may reach, or as otherwise required under the dispute resolution provisions of this Contract or applicable Laws and Regulations.

C. If no other special agreement is reached, Contractor shall repair or replace the damaged Work, using allocated insurance proceeds.

## ARTICLE 7 — CONTRACTOR'S RESPONSIBILITIES

7.01 Contractor's Means And Methods Of Construction

A. Contractor shall be solely responsible for the means, methods, techniques, sequences, and procedures of construction.

B. If the Contract Documents note, or Contractor determines, that professional engineering or other design services are needed to carry out Contractor's responsibilities for construction means, methods, techniques, sequences, and procedures, or for Site safety, then Contractor shall cause such services to be provided by a properly licensed design professional, at Contractor's expense. Such services are not Owner-delegated professional design services under this Contract, and neither Owner nor Engineer has any responsibility with respect to (1) Contractor's determination of the need for such services, (2) the qualifications or licensing of the design professionals retained or employed by Contractor, (3) the performance of such services, or (4) any errors, omissions, or defects in such services.

7.02 Supervision and Superintendence

A. Contractor shall supervise, inspect, and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with the Contract Documents.

B. At all times during the progress of the Work, Contractor shall assign a competent resident superintendent who will not be replaced without written notice to Owner and Engineer except under extraordinary circumstances.

7.03 Labor; Working Hours

A. Contractor shall provide competent, suitably qualified personnel to survey and lay out the Work and perform construction as required by the Contract Documents. Contractor shall maintain good discipline and order at the Site.

B. Contractor shall be fully responsible to Owner and Engineer for all acts and omissions of Contractor's employees; of Suppliers and Subcontractors, and their employees; and of any other individuals or entities performing or furnishing any of the Work, just as Contractor is responsible for Contractor's own acts and omissions.

C. Except as otherwise required for the safety or protection of persons or the Work or property at the Site or adjacent thereto, and except as otherwise stated in the Contract Documents, all Work at the Site will be performed during regular working hours, Monday through Friday. Contractor will not perform Work on a Saturday, Sunday, or any legal holiday. Contractor may perform Work outside regular working hours or on Saturdays, Sundays, or legal holidays only with Owner's written consent, which will not be unreasonably withheld.

7.04 Services, Materials, and Equipment

A. Unless otherwise specified in the Contract Documents, Contractor shall provide and assume full responsibility for all services, materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, telephone, water, sanitary facilities, temporary facilities, and all other facilities and incidentals necessary for the performance, testing, start up, and completion of the Work, whether or not such items are specifically called for in the Contract Documents.

B. All materials and equipment incorporated into the Work must be new and of good quality, except as otherwise provided in the Contract Documents. All special warranties and guarantees required by the Specifications will expressly run to the benefit of Owner. If required by Engineer, Contractor shall furnish satisfactory evidence (including reports of required tests) as to the source, kind, and quality of materials and equipment.

C. All materials and equipment must be stored, applied, installed, connected, erected, protected, used, cleaned, and conditioned in accordance with instructions of the applicable Supplier, except as otherwise may be provided in the Contract Documents.

7.05 "Or Equals"

A. *Contractor's Request; Governing Criteria*: Whenever an item of equipment or material is specified or described in the Contract Documents by using the names of one or more proprietary items or specific Suppliers, the Contract Price has been based upon Contractor furnishing such item as specified. The specification or description of such an item is intended to establish the type, function, appearance, and quality required. Unless the specification or description contains or is followed by words reading that no like, equivalent, or "or equal" item is permitted, Contractor may request that Engineer authorize the use of other items of equipment or material, or items from other proposed Suppliers, under the circumstances described below.

1. If Engineer in its sole discretion determines that an item of equipment or material proposed by Contractor is functionally equal to that named and

sufficiently similar so that no change in related Work will be required, Engineer will deem it an "or equal" item. For the purposes of this paragraph, a proposed item of equipment or material will be considered functionally equal to an item so named if:

a. in the exercise of reasonable judgment Engineer determines that the proposed item:
    1) is at least equal in materials of construction, quality, durability, appearance, strength, and design characteristics;
    2) will reliably perform at least equally well the function and achieve the results imposed by the design concept of the completed Project as a functioning whole;
    3) has a proven record of performance and availability of responsive service; and
    4) is not objectionable to Owner.
b. Contractor certifies that, if the proposed item is approved and incorporated into the Work:
    1) there will be no increase in cost to the Owner or increase in Contract Times; and
    2) the item will conform substantially to the detailed requirements of the item named in the Contract Documents.

B. *Contractor's Expense*: Contractor shall provide all data in support of any proposed "or equal" item at Contractor's expense.

C. *Engineer's Evaluation and Determination*: Engineer will be allowed a reasonable time to evaluate each "or-equal" request. Engineer may require Contractor to furnish additional data about the proposed "or-equal" item. Engineer will be the sole judge of acceptability. No "or-equal" item will be ordered, furnished, installed, or utilized until Engineer's review is complete and Engineer determines that the proposed item is an "or-equal," which will be evidenced by an approved Shop Drawing or other written communication. Engineer will advise Contractor in writing of any negative determination.

D. *Effect of Engineer's Determination*: Neither approval nor denial of an "or-equal" request will result in any change in Contract Price. The Engineer's denial of an "or-equal" request will be final and binding, and may not be reversed through an appeal under any provision of the Contract.

E. *Treatment as a Substitution Request*: If Engineer determines that an item of equipment or material proposed by Contractor does not qualify as an "or-equal" item, Contractor may request that Engineer consider the item a proposed substitute pursuant to Paragraph 7.06.

7.06 Substitutes

A. *Contractor's Request; Governing Criteria*: Unless the specification or description of an item of equipment or material required to be furnished under the Contract Documents contains or is followed by words reading that no substitution is permitted, Contractor may request that Engineer authorize the use of other items of equipment or material under the circumstances described below. To the extent possible such requests must be made before commencement of related construction at the Site.

1. Contractor shall submit sufficient information as provided below to allow Engineer to determine if the item of material or equipment proposed is

functionally equivalent to that named and an acceptable substitute therefor. Engineer will not accept requests for review of proposed substitute items of equipment or material from anyone other than Contractor.

2. The requirements for review by Engineer will be as set forth in Paragraph 7.06.B, as supplemented by the Specifications, and as Engineer may decide is appropriate under the circumstances.
3. Contractor shall make written application to Engineer for review of a proposed substitute item of equipment or material that Contractor seeks to furnish or use. The application:
    a. will certify that the proposed substitute item will:
        1) perform adequately the functions and achieve the results called for by the general design;
        2) be similar in substance to the item specified; and
        3) be suited to the same use as the item specified.
    b. will state:
        1) the extent, if any, to which the use of the proposed substitute item will necessitate a change in Contract Times;
        2) whether use of the proposed substitute item in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with Owner for other work on the Project) to adapt the design to the proposed substitute item; and
        3) whether incorporation or use of the proposed substitute item in connection with the Work is subject to payment of any license fee or royalty.
    c. will identify:
        1) all variations of the proposed substitute item from the item specified; and
        2) available engineering, sales, maintenance, repair, and replacement services.
    d. will contain an itemized estimate of all costs or credits that will result directly or indirectly from use of such substitute item, including but not limited to changes in Contract Price, shared savings, costs of redesign, and claims of other contractors affected by any resulting change.

B. *Engineer's Evaluation and Determination*: Engineer will be allowed a reasonable time to evaluate each substitute request, and to obtain comments and direction from Owner. Engineer may require Contractor to furnish additional data about the proposed substitute item. Engineer will be the sole judge of acceptability. No substitute will be ordered, furnished, installed, or utilized until Engineer's review is complete and Engineer determines that the proposed item is an acceptable substitute. Engineer's determination will be evidenced by a Field Order or a proposed Change Order accounting for the substitution itself and all related impacts, including changes in Contract Price or Contract Times. Engineer will advise Contractor in writing of any negative determination.

C. *Special Guarantee*: Owner may require Contractor to furnish at Contractor's expense a special performance guarantee or other surety with respect to any substitute.

D. *Reimbursement of Engineer's Cost*: Engineer will record Engineer's costs in evaluating a substitute proposed or submitted by Contractor. Whether or not Engineer approves a substitute so proposed or submitted by Contractor, Contractor

shall reimburse Owner for the reasonable charges of Engineer for evaluating each such proposed substitute. Contractor shall also reimburse Owner for the reasonable charges of Engineer for making changes in the Contract Documents (or in the provisions of any other direct contract with Owner) resulting from the acceptance of each proposed substitute.

E. *Contractor's Expense*: Contractor shall provide all data in support of any proposed substitute at Contractor's expense.

F. *Effect of Engineer's Determination*: If Engineer approves the substitution request, Contractor shall execute the proposed Change Order and proceed with the substitution. The Engineer's denial of a substitution request will be final and binding, and may not be reversed through an appeal under any provision of the Contract. Contractor may challenge the scope of reimbursement costs imposed under Paragraph 7.06.D, by timely submittal of a Change Proposal.

7.07 Concerning Subcontractors and Suppliers

A. Contractor may retain Subcontractors and Suppliers for the performance of parts of the Work. Such Subcontractors and Suppliers must be acceptable to Owner. The Contractor's retention of a Subcontractor or Supplier for the performance of parts of the Work will not relieve Contractor's obligation to Owner to perform and complete the Work in accordance with the Contract Documents.

B. Contractor shall retain specific Subcontractors and Suppliers for the performance of designated parts of the Work if required by the Contract to do so.

C. Subsequent to the submittal of Contractor's Bid or final negotiation of the terms of the Contract, Owner may not require Contractor to retain any Subcontractor or Supplier to furnish or perform any of the Work against which Contractor has reasonable objection.

D. Prior to entry into any binding subcontract or purchase order, Contractor shall submit to Owner the identity of the proposed Subcontractor or Supplier (unless Owner has already deemed such proposed Subcontractor or Supplier acceptable during the bidding process or otherwise). Such proposed Subcontractor or Supplier shall be deemed acceptable to Owner unless Owner raises a substantive, reasonable objection within 5 days.

E. Owner may require the replacement of any Subcontractor or Supplier. Owner also may require Contractor to retain specific replacements; provided, however, that Owner may not require a replacement to which Contractor has a reasonable objection. If Contractor has submitted the identity of certain Subcontractors or Suppliers for acceptance by Owner, and Owner has accepted it (either in writing or by failing to make written objection thereto), then Owner may subsequently revoke the acceptance of any such Subcontractor or Supplier so identified solely on the basis of substantive, reasonable objection after due investigation. Contractor shall submit an acceptable replacement for the rejected Subcontractor or Supplier.

F. If Owner requires the replacement of any Subcontractor or Supplier retained by Contractor to perform any part of the Work, then Contractor shall be entitled to an adjustment in Contract Price or Contract Times, with respect to the replacement; and Contractor shall initiate a Change Proposal for such adjustment within 30 days of Owner's requirement of replacement.

G. No acceptance by Owner of any such Subcontractor or Supplier, whether initially or as a replacement, will constitute a waiver of the right of Owner to the completion of the Work in accordance with the Contract Documents.

H. On a monthly basis, Contractor shall submit to Engineer a complete list of all Subcontractors and Suppliers having a direct contract with Contractor, and of all other Subcontractors and Suppliers known to Contractor at the time of submittal.

I. Contractor shall be solely responsible for scheduling and coordinating the work of Subcontractors and Suppliers.

J. The divisions and sections of the Specifications and the identifications of any Drawings do not control Contractor in dividing the Work among Subcontractors or Suppliers, or in delineating the Work to be performed by any specific trade.

K. All Work performed for Contractor by a Subcontractor or Supplier must be pursuant to an appropriate contractual agreement that specifically binds the Subcontractor or Supplier to the applicable terms and conditions of the Contract for the benefit of Owner and Engineer.

L. Owner may furnish to any Subcontractor or Supplier, to the extent practicable, information about amounts paid to Contractor for Work performed for Contractor by the Subcontractor or Supplier.

M. Contractor shall restrict all Subcontractors and Suppliers from communicating with Engineer or Owner, except through Contractor or in case of an emergency, or as otherwise expressly allowed in this Contract.

7.08 Patent Fees and Royalties

A. Contractor shall pay all license fees and royalties and assume all costs incident to the use in the performance of the Work or the incorporation in the Work of any invention, design, process, product, or device which is the subject of patent rights or copyrights held by others. If an invention, design, process, product, or device is specified in the Contract Documents for use in the performance of the Work and if, to the actual knowledge of Owner or Engineer, its use is subject to patent rights or copyrights calling for the payment of any license fee or royalty to others, the existence of such rights will be disclosed in the Contract Documents.

B. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, and its officers, directors, members, partners, employees, agents, consultants, and subcontractors, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device specified in the Contract Documents, but not identified as being subject to payment of any license fee or royalty to others required by patent rights or copyrights.

C. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out

of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device not specified in the Contract Documents.

7.09 Permits

A. Unless otherwise provided in the Contract Documents, Contractor shall obtain and pay for all construction permits, licenses, and certificates of occupancy. Owner shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the Work which are applicable at the time of the submission of Contractor's Bid (or when Contractor became bound under a negotiated contract). Owner shall pay all charges of utility owners for connections for providing permanent service to the Work.

7.10 Taxes

A. Contractor shall pay all sales, consumer, use, and other similar taxes required to be paid by Contractor in accordance with the Laws and Regulations of the place of the Project which are applicable during the performance of the Work.

7.11 Laws and Regulations

A. Contractor shall give all notices required by and shall comply with all Laws and Regulations applicable to the performance of the Work. Neither Owner nor Engineer shall be responsible for monitoring Contractor's compliance with any Laws or Regulations.

B. If Contractor performs any Work or takes any other action knowing or having reason to know that it is contrary to Laws or Regulations, Contractor shall bear all resulting costs and losses, and shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such Work or other action. It is not Contractor's responsibility to make certain that the Work described in the Contract Documents is in accordance with Laws and Regulations, but this does not relieve Contractor of its obligations under Paragraph 3.03.

C. Owner or Contractor may give written notice to the other party of any changes after the submission of Contractor's Bid (or after the date when Contractor became bound under a negotiated contract) in Laws or Regulations having an effect on the cost or time of performance of the Work, including but not limited to changes in Laws or Regulations having an effect on procuring permits and on sales, use, value-added, consumption, and other similar taxes. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times resulting from such changes, then within 30 days of such written notice Contractor may submit a Change Proposal, or Owner may initiate a Claim.

7.12 Record Documents

A. Contractor shall maintain in a safe place at the Site one printed record copy of all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field

Orders, written interpretations and clarifications, and approved Shop Drawings. Contractor shall keep such record documents in good order and annotate them to show changes made during construction. These record documents, together with all approved Samples, will be available to Engineer for reference. Upon completion of the Work, Contractor shall deliver these record documents to Engineer.

7.13 Safety and Protection

A. Contractor shall be solely responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the Work. Such responsibility does not relieve Subcontractors of their responsibility for the safety of persons or property in the performance of their work, nor for compliance with applicable safety Laws and Regulations.

B. Contractor shall designate a qualified and experienced safety representative whose duties and responsibilities are the prevention of Work-related accidents and the maintenance and supervision of safety precautions and programs.

C. Contractor shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury, or loss to:
   1. all persons on the Site or who may be affected by the Work;
   2. all the Work and materials and equipment to be incorporated therein, whether in storage on or off the Site; and
   3. other property at the Site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, other work in progress, utilities, and Underground Facilities not designated for removal, relocation, or replacement in the course of construction.

D. All damage, injury, or loss to any property referred to in Paragraph 7.13.C.2 or 7.13.C.3 caused, directly or indirectly, in whole or in part, by Contractor, any Subcontractor, Supplier, or any other individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, shall be remedied by Contractor at its expense (except damage or loss attributable to the fault of Drawings or Specifications or to the acts or omissions of Owner or Engineer or anyone employed by any of them, or anyone for whose acts any of them may be liable, and not attributable, directly or indirectly, in whole or in part, to the fault or negligence of Contractor or any Subcontractor, Supplier, or other individual or entity directly or indirectly employed by any of them).

E. Contractor shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection.

F. Contractor shall notify Owner; the owners of adjacent property; the owners of Underground Facilities and other utilities (if the identity of such owners is known to Contractor); and other contractors and utility owners performing work at or adjacent to the Site, in writing, when Contractor knows that prosecution of the Work may affect them, and shall cooperate with them in the protection, removal, relocation, and replacement of their property or work in progress.

G. Contractor shall comply with the applicable requirements of Owner's safety programs, if any. Any Owner's safety programs that are applicable to the Work are identified or included in the Supplementary Conditions or Specifications.

H. Contractor shall inform Owner and Engineer of the specific requirements of Contractor's safety program with which Owner's and Engineer's employees and representatives must comply while at the Site.

I. Contractor's duties and responsibilities for safety and protection will continue until all the Work is completed, Engineer has issued a written notice to Owner and Contractor in accordance with Paragraph 15.06.C that the Work is acceptable, and Contractor has left the Site (except as otherwise expressly provided in connection with Substantial Completion).

J. Contractor's duties and responsibilities for safety and protection will resume whenever Contractor or any Subcontractor or Supplier returns to the Site to fulfill warranty or correction obligations, or to conduct other tasks arising from the Contract Documents.

7.14 Hazard Communication Programs

A. Contractor shall be responsible for coordinating any exchange of safety data sheets (formerly known as material safety data sheets) or other hazard communication information required to be made available to or exchanged between or among employers at the Site in accordance with Laws or Regulations.

7.15 Emergencies

A. In emergencies affecting the safety or protection of persons or the Work or property at the Site or adjacent thereto, Contractor is obligated to act to prevent damage, injury, or loss. Contractor shall give Engineer prompt written notice if Contractor believes that any significant changes in the Work or variations from the Contract Documents have been caused by an emergency, or are required as a result of Contractor's response to an emergency. If Engineer determines that a change in the Contract Documents is required because of an emergency or Contractor's response, a Work Change Directive or Change Order will be issued.

7.16 Submittals

A. *Shop Drawing and Sample Requirements*
   1. Before submitting a Shop Drawing or Sample, Contractor shall:
      a. review and coordinate the Shop Drawing or Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents;
      b. determine and verify:
         1) all field measurements, quantities, dimensions, specified performance and design criteria, installation requirements, materials, catalog numbers, and similar information with respect to the Submittal;
         2) the suitability of all materials and equipment offered with respect to the indicated application, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work; and
         3) all information relative to Contractor's responsibilities for means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incident thereto;
      c. confirm that the Submittal is complete with respect to all related data included in the Submittal.
   2. Each Shop Drawing or Sample must bear a stamp or specific written certification that Contractor has satisfied Contractor's obligations under the

Contract Documents with respect to Contractor's review of that Submittal, and that Contractor approves the Submittal.

3. With each Shop Drawing or Sample, Contractor shall give Engineer specific written notice of any variations that the Submittal may have from the requirements of the Contract Documents. This notice must be set forth in a written communication separate from the Submittal; and, in addition, in the case of a Shop Drawing by a specific notation made on the Shop Drawing itself.

B. *Submittal Procedures for Shop Drawings and Samples*: Contractor shall label and submit Shop Drawings and Samples to Engineer for review and approval in accordance with the accepted Schedule of Submittals.

1. *Shop Drawings*
   a. Contractor shall submit the number of copies required in the Specifications.
   b. Data shown on the Shop Drawings must be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Engineer the services, materials, and equipment Contractor proposes to provide, and to enable Engineer to review the information for the limited purposes required by Paragraph 7.16.C.
2. *Samples*
   a. Contractor shall submit the number of Samples required in the Specifications.
   b. Contractor shall clearly identify each Sample as to material, Supplier, pertinent data such as catalog numbers, the use for which intended and other data as Engineer may require to enable Engineer to review the Submittal for the limited purposes required by Paragraph 7.16.C.
3. Where a Shop Drawing or Sample is required by the Contract Documents or the Schedule of Submittals, any related Work performed prior to Engineer's review and approval of the pertinent submittal will be at the sole expense and responsibility of Contractor.

C. *Engineer's Review of Shop Drawings and Samples*

1. Engineer will provide timely review of Shop Drawings and Samples in accordance with the accepted Schedule of Submittals. Engineer's review and approval will be only to determine if the items covered by the Submittals will, after installation or incorporation in the Work, comply with the requirements of the Contract Documents, and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.
2. Engineer's review and approval will not extend to means, methods, techniques, sequences, or procedures of construction, or to safety precautions or programs incident thereto.
3. Engineer's review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.
4. Engineer's review and approval of a Shop Drawing or Sample will not relieve Contractor from responsibility for any variation from the requirements of the Contract Documents unless Contractor has complied with the requirements of Paragraph 7.16.A.3 and Engineer has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample. Engineer will document any such approved variation from the requirements of the Contract Documents in a Field Order or other appropriate Contract modification.

5. Engineer's review and approval of a Shop Drawing or Sample will not relieve Contractor from responsibility for complying with the requirements of Paragraphs 7.16.A and B.
6. Engineer's review and approval of a Shop Drawing or Sample, or of a variation from the requirements of the Contract Documents, will not, under any circumstances, change the Contract Times or Contract Price, unless such changes are included in a Change Order.
7. Neither Engineer's receipt, review, acceptance, or approval of a Shop Drawing or Sample will result in such item becoming a Contract Document.
8. Contractor shall perform the Work in compliance with the requirements and commitments set forth in approved Shop Drawings and Samples, subject to the provisions of Paragraph 7.16.C.4.

D. *Resubmittal Procedures for Shop Drawings and Samples*
1. Contractor shall make corrections required by Engineer and shall return the required number of corrected copies of Shop Drawings and submit, as required, new Samples for review and approval. Contractor shall direct specific attention in writing to revisions other than the corrections called for by Engineer on previous Submittals.
2. Contractor shall furnish required Shop Drawing and Sample submittals with sufficient information and accuracy to obtain required approval of an item with no more than two resubmittals. Engineer will record Engineer's time for reviewing a third or subsequent resubmittal of a Shop Drawing or Sample, and Contractor shall be responsible for Engineer's charges to Owner for such time. Owner may impose a set-off against payments due Contractor to secure reimbursement for such charges.
3. If Contractor requests a change of a previously approved Shop Drawing or Sample, Contractor shall be responsible for Engineer's charges to Owner for its review time, and Owner may impose a set-off against payments due Contractor to secure reimbursement for such charges, unless the need for such change is beyond the control of Contractor.

E. *Submittals Other than Shop Drawings, Samples, and Owner-Delegated Designs*
1. The following provisions apply to all Submittals other than Shop Drawings, Samples, and Owner-delegated designs:
    a. Contractor shall submit all such Submittals to the Engineer in accordance with the Schedule of Submittals and pursuant to the applicable terms of the Contract Documents.
    b. Engineer will provide timely review of all such Submittals in accordance with the Schedule of Submittals and return such Submittals with a notation of either Accepted or Not Accepted. Any such Submittal that is not returned within the time established in the Schedule of Submittals will be deemed accepted.
    c. Engineer's review will be only to determine if the Submittal is acceptable under the requirements of the Contract Documents as to general form and content of the Submittal.
    d. If any such Submittal is not accepted, Contractor shall confer with Engineer regarding the reason for the non-acceptance, and resubmit an acceptable document.
2. Procedures for the submittal and acceptance of the Progress Schedule, the Schedule of Submittals, and the Schedule of Values are set forth in Paragraphs 2.03. 2.04, and 2.05.

F. Owner-delegated Designs: Submittals pursuant to Owner-delegated designs are governed by the provisions of Paragraph 7.19.

7.17 Contractor's General Warranty and Guarantee

A. Contractor warrants and guarantees to Owner that all Work will be in accordance with the Contract Documents and will not be defective. Engineer is entitled to rely on Contractor's warranty and guarantee.

B. Owner's rights under this warranty and guarantee are in addition to, and are not limited by, Owner's rights under the correction period provisions of Paragraph 15.08. The time in which Owner may enforce its warranty and guarantee rights under this Paragraph 7.17 is limited only by applicable Laws and Regulations restricting actions to enforce such rights; provided, however, that after the end of the correction period under Paragraph 15.08:
   1. Owner shall give Contractor written notice of any defective Work within 60 days of the discovery that such Work is defective; and
   2. Such notice will be deemed the start of an event giving rise to a Claim under Paragraph 12.01.B, such that any related Claim must be brought within 30 days of the notice.

C. Contractor's warranty and guarantee hereunder excludes defects or damage caused by:
   1. abuse, or improper modification, maintenance, or operation, by persons other than Contractor, Subcontractors, Suppliers, or any other individual or entity for whom Contractor is responsible; or
   2. normal wear and tear under normal usage.

D. Contractor's obligation to perform and complete the Work in accordance with the Contract Documents is absolute. None of the following will constitute an acceptance of Work that is not in accordance with the Contract Documents, a release of Contractor's obligation to perform the Work in accordance with the Contract Documents, or a release of Owner's warranty and guarantee rights under this Paragraph 7.17:
   1. Observations by Engineer;
   2. Recommendation by Engineer or payment by Owner of any progress or final payment;
   3. The issuance of a certificate of Substantial Completion by Engineer or any payment related thereto by Owner;
   4. Use or occupancy of the Work or any part thereof by Owner;
   5. Any review and approval of a Shop Drawing or Sample submittal;
   6. The issuance of a notice of acceptability by Engineer;
   7. The end of the correction period established in Paragraph 15.08;
   8. Any inspection, test, or approval by others; or
   9. Any correction of defective Work by Owner.

E. If the Contract requires the Contractor to accept the assignment of a contract entered into by Owner, then the specific warranties, guarantees, and correction obligations contained in the assigned contract will govern with respect to Contractor's performance obligations to Owner for the Work described in the assigned contract.

7.18 Indemnification

A. To the fullest extent permitted by Laws and Regulations, and in addition to any other obligations of Contractor under the Contract or otherwise, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, from losses, damages, costs, and judgments (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court or arbitration or other dispute resolution costs) arising from third-party claims or actions relating to or resulting from the performance or furnishing of the Work, provided that any such claim, action, loss, cost, judgment or damage is attributable to bodily injury, sickness, disease, or death, or to damage to or destruction of tangible property (other than the Work itself), including the loss of use resulting therefrom, but only to the extent caused by any negligent act or omission of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable.

B. In any and all claims against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, by any employee (or the survivor or personal representative of such employee) of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, the indemnification obligation under Paragraph 7.18.A will not be limited in any way by any limitation on the amount or type of damages, compensation, or benefits payable by or for Contractor or any such Subcontractor, Supplier, or other individual or entity under workers' compensation acts, disability benefit acts, or other employee benefit acts.

7.19 Delegation of Professional Design Services

A. Owner may require Contractor to provide professional design services for a portion of the Work by express delegation in the Contract Documents. Such delegation will specify the performance and design criteria that such services must satisfy, and the Submittals that Contractor must furnish to Engineer with respect to the Owner-delegated design.

B. Contractor shall cause such Owner-delegated professional design services to be provided pursuant to the professional standard of care by a properly licensed design professional, whose signature and seal must appear on all drawings, calculations, specifications, certifications, and Submittals prepared by such design professional. Such design professional must issue all certifications of design required by Laws and Regulations.

C. If a Shop Drawing or other Submittal related to the Owner-delegated design is prepared by Contractor, a Subcontractor, or others for submittal to Engineer, then such Shop Drawing or other Submittal must bear the written approval of Contractor's design professional when submitted by Contractor to Engineer.

D. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy, and completeness of the services, certifications, and approvals performed or provided by the design professionals retained or employed by Contractor under an Owner-delegated design, subject to the professional standard of care and the performance and design criteria stated in the Contract Documents.

E. Pursuant to this Paragraph 7.19, Engineer's review, approval, and other determinations regarding design drawings, calculations, specifications, certifications, and other Submittals furnished by Contractor pursuant to an Owner-delegated design will be only for the following limited purposes:
   1. Checking for conformance with the requirements of this Paragraph 7.19;
   2. Confirming that Contractor (through its design professionals) has used the performance and design criteria specified in the Contract Documents; and
   3. Establishing that the design furnished by Contractor is consistent with the design concept expressed in the Contract Documents.

F. Contractor shall not be responsible for the adequacy of performance or design criteria specified by Owner or Engineer.

G. Contractor is not required to provide professional services in violation of applicable Laws and Regulations.

## ARTICLE 8 — OTHER WORK AT THE SITE

8.01 Other Work

A. In addition to and apart from the Work under the Contract Documents, the Owner may perform other work at or adjacent to the Site. Such other work may be performed by Owner's employees, or through contracts between the Owner and third parties. Owner may also arrange to have third-party utility owners perform work on their utilities and facilities at or adjacent to the Site.

B. If Owner performs other work at or adjacent to the Site with Owner's employees, or through contracts for such other work, then Owner shall give Contractor written notice thereof prior to starting any such other work. If Owner has advance information regarding the start of any third-party utility work that Owner has arranged to take place at or adjacent to the Site, Owner shall provide such information to Contractor.

C. Contractor shall afford proper and safe access to the Site to each contractor that performs such other work, each utility owner performing other work, and Owner, if Owner is performing other work with Owner's employees, and provide a reasonable opportunity for the introduction and storage of materials and equipment and the execution of such other work.

D. Contractor shall do all cutting, fitting, and patching of the Work that may be required to properly connect or otherwise make its several parts come together and properly integrate with such other work. Contractor shall not endanger any work of others by cutting, excavating, or otherwise altering such work; provided, however, that Contractor may cut or alter others' work with the written consent of Engineer and the others whose work will be affected.

E. If the proper execution or results of any part of Contractor's Work depends upon work performed by others, Contractor shall inspect such other work and promptly report to Engineer in writing any delays, defects, or deficiencies in such other work that render it unavailable or unsuitable for the proper execution and results of Contractor's Work. Contractor's failure to so report will constitute an acceptance of such other work as fit and proper for integration with Contractor's Work except for latent defects and deficiencies in such other work.

F. The provisions of this article are not applicable to work that is performed by third-party utilities or other third-party entities without a contract with Owner, or that is

performed without having been arranged by Owner. If such work occurs, then any related delay, disruption, or interference incurred by Contractor is governed by the provisions of Paragraph 4.05.C.3.

8.02 Coordination

A. If Owner intends to contract with others for the performance of other work at or adjacent to the Site, to perform other work at or adjacent to the Site with Owner's employees, or to arrange to have utility owners perform work at or adjacent to the Site, the following will be set forth in the Supplementary Conditions or provided to Contractor prior to the start of any such other work:
   1. The identity of the individual or entity that will have authority and responsibility for coordination of the activities among the various contractors;
   2. An itemization of the specific matters to be covered by such authority and responsibility; and
   3. The extent of such authority and responsibilities.

B. Unless otherwise provided in the Supplementary Conditions, Owner shall have sole authority and responsibility for such coordination.

8.03 Legal Relationships

A. If, in the course of performing other work for Owner at or adjacent to the Site, the Owner's employees, any other contractor working for Owner, or any utility owner that Owner has arranged to perform work, causes damage to the Work or to the property of Contractor or its Subcontractors, or delays, disrupts, interferes with, or increases the scope or cost of the performance of the Work, through actions or inaction, then Contractor shall be entitled to an equitable adjustment in the Contract Price or the Contract Times. Contractor must submit any Change Proposal seeking an equitable adjustment in the Contract Price or the Contract Times under this paragraph within 30 days of the damaging, delaying, disrupting, or interfering event. The entitlement to, and extent of, any such equitable adjustment will take into account information (if any) regarding such other work that was provided to Contractor in the Contract Documents prior to the submittal of the Bid or the final negotiation of the terms of the Contract, and any remedies available to Contractor under Laws or Regulations concerning utility action or inaction. When applicable, any such equitable adjustment in Contract Price will be conditioned on Contractor assigning to Owner all Contractor's rights against such other contractor or utility owner with respect to the damage, delay, disruption, or interference that is the subject of the adjustment. Contractor's entitlement to an adjustment of the Contract Times or Contract Price is subject to the provisions of Paragraphs 4.05.D and 4.05.E.

B. Contractor shall take reasonable and customary measures to avoid damaging, delaying, disrupting, or interfering with the work of Owner, any other contractor, or any utility owner performing other work at or adjacent to the Site.
   1. If Contractor fails to take such measures and as a result damages, delays, disrupts, or interferes with the work of any such other contractor or utility owner, then Owner may impose a set-off against payments due Contractor, and assign to such other contractor or utility owner the Owner's contractual rights against Contractor with respect to the breach of the obligations set forth in this Paragraph 8.03.B.
   2. When Owner is performing other work at or adjacent to the Site with Owner's employees, Contractor shall be liable to Owner for damage to such other work,

and for the reasonable direct delay, disruption, and interference costs incurred by Owner as a result of Contractor's failure to take reasonable and customary measures with respect to Owner's other work. In response to such damage, delay, disruption, or interference, Owner may impose a set-off against payments due Contractor.

C. If Contractor damages, delays, disrupts, or interferes with the work of any other contractor, or any utility owner performing other work at or adjacent to the Site, through Contractor's failure to take reasonable and customary measures to avoid such impacts, or if any claim arising out of Contractor's actions, inactions, or negligence in performance of the Work at or adjacent to the Site is made by any such other contractor or utility owner against Contractor, Owner, or Engineer, then Contractor shall (1) promptly attempt to settle the claim as to all parties through negotiations with such other contractor or utility owner, or otherwise resolve the claim by arbitration or other dispute resolution proceeding or at law, and (2) indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against any such claims, and against all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such damage, delay, disruption, or interference.

## ARTICLE 9 — OWNER'S RESPONSIBILITIES

9.01 Communications to Contractor

A. Except as otherwise provided in these General Conditions, Owner shall issue all communications to Contractor through Engineer.

9.02 Replacement of Engineer

A. Owner may at its discretion appoint an engineer to replace Engineer, provided Contractor makes no reasonable objection to the replacement engineer. The replacement engineer's status under the Contract Documents will be that of the former Engineer.

9.03 Furnish Data

A. Owner shall promptly furnish the data required of Owner under the Contract Documents.

9.04 Pay When Due

A. Owner shall make payments to Contractor when they are due as provided in the Agreement.

9.05 Lands and Easements; Reports, Tests, and Drawings

A. Owner's duties with respect to providing lands and easements are set forth in Paragraph 5.01.

A. Owner's duties with respect to providing engineering surveys to establish reference points are set forth in Paragraph 4.03.

B. Article 5 refers to Owner's identifying and making available to Contractor copies of reports of explorations and tests of conditions at the Site, and drawings of physical conditions relating to existing surface or subsurface structures at the Site.

9.06 Insurance

A. Owner's responsibilities, if any, with respect to purchasing and maintaining liability and property insurance are set forth in Article 6.

9.07 Change Orders

A. Owner's responsibilities with respect to Change Orders are set forth in Article 11.

9.08 Inspections, Tests, and Approvals

A. Owner's responsibility with respect to certain inspections, tests, and approvals is set forth in Paragraph 14.02.B.

9.09 Limitations on Owner's Responsibilities

A. The Owner shall not supervise, direct, or have control or authority over, nor be responsible for, Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Owner will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

9.10 Undisclosed Hazardous Environmental Condition

A. Owner's responsibility in respect to an undisclosed Hazardous Environmental Condition is set forth in Paragraph 5.06.

9.11 Evidence of Financial Arrangements

A. Upon request of Contractor, Owner shall furnish Contractor reasonable evidence that financial arrangements have been made to satisfy Owner's obligations under the Contract (including obligations under proposed changes in the Work).

9.12 Safety Programs

A. While at the Site, Owner's employees and representatives shall comply with the specific applicable requirements of Contractor's safety programs of which Owner has been informed.

B. Owner shall furnish copies of any applicable Owner safety programs to Contractor.

## ARTICLE 10 — ENGINEER'S STATUS DURING CONSTRUCTION

10.01 Owner's Representative

A. Engineer will be Owner's representative during the construction period. The duties and responsibilities and the limitations of authority of Engineer as Owner's representative during construction are set forth in the Contract.

10.02 Visits to Site

A. Engineer will make visits to the Site at intervals appropriate to the various stages of construction as Engineer deems necessary in order to observe, as an experienced and qualified design professional, the progress that has been made and the quality of the various aspects of Contractor's executed Work. Based on information obtained during such visits and observations, Engineer, for the benefit of Owner, will determine, in general, if the Work is proceeding in accordance with the Contract Documents. Engineer will not be required to make exhaustive or continuous inspections on the Site to check the quality or quantity of the Work. Engineer's

efforts will be directed toward providing for Owner a greater degree of confidence that the completed Work will conform generally to the Contract Documents. On the basis of such visits and observations, Engineer will keep Owner informed of the progress of the Work and will endeavor to guard Owner against defective Work.

B. Engineer's visits and observations are subject to all the limitations on Engineer's authority and responsibility set forth in Paragraph 10.07. Particularly, but without limitation, during or as a result of Engineer's visits or observations of Contractor's Work, Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work.

10.03 Resident Project Representative

A. If Owner and Engineer have agreed that Engineer will furnish a Resident Project Representative to represent Engineer at the Site and assist Engineer in observing the progress and quality of the Work, then the authority and responsibilities of any such Resident Project Representative will be as provided in the Supplementary Conditions, and limitations on the responsibilities thereof will be as provided in the Supplementary Conditions and in Paragraph 10.07.

B. If Owner designates an individual or entity who is not Engineer's consultant, agent, or employee to represent Owner at the Site, then the responsibilities and authority of such individual or entity will be as provided in the Supplementary Conditions.

10.04 Engineer's Authority

A. Engineer has the authority to reject Work in accordance with Article 14.

B. Engineer's authority as to Submittals is set forth in Paragraph 7.16.

C. Engineer's authority as to design drawings, calculations, specifications, certifications and other Submittals from Contractor in response to Owner's delegation (if any) to Contractor of professional design services, is set forth in Paragraph 7.19.

D. Engineer's authority as to changes in the Work is set forth in Article 11.

E. Engineer's authority as to Applications for Payment is set forth in Article 15.

10.05 Determinations for Unit Price Work

A. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor as set forth in Paragraph 13.03.

10.06 Decisions on Requirements of Contract Documents and Acceptability of Work

A. Engineer will render decisions regarding the requirements of the Contract Documents, and judge the acceptability of the Work, pursuant to the specific procedures set forth herein for initial interpretations, Change Proposals, and acceptance of the Work. In rendering such decisions and judgments, Engineer will not show partiality to Owner or Contractor, and will not be liable to Owner, Contractor, or others in connection with any proceedings, interpretations, decisions, or judgments conducted or rendered in good faith.

10.07 Limitations on Engineer's Authority and Responsibilities

A. Neither Engineer's authority or responsibility under this Article 10 or under any other provision of the Contract, nor any decision made by Engineer in good faith either to exercise or not exercise such authority or responsibility or the undertaking, exercise, or performance of any authority or responsibility by Engineer, will create, impose, or give rise to any duty in contract, tort, or otherwise owed by Engineer to Contractor, any Subcontractor, any Supplier, any other individual or entity, or to any surety for or employee or agent of any of them.

B. Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Engineer will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

C. Engineer will not be responsible for the acts or omissions of Contractor or of any Subcontractor, any Supplier, or of any other individual or entity performing any of the Work.

D. Engineer's review of the final Application for Payment and accompanying documentation, and all maintenance and operating instructions, schedules, guarantees, bonds, certificates of inspection, tests and approvals, and other documentation required to be delivered by Contractor under Paragraph 15.06.A, will only be to determine generally that their content complies with the requirements of, and in the case of certificates of inspections, tests, and approvals, that the results certified indicate compliance with the Contract Documents.

E. The limitations upon authority and responsibility set forth in this Paragraph 10.07 also apply to the Resident Project Representative, if any.

10.08 Compliance with Safety Program

A. While at the Site, Engineer's employees and representatives will comply with the specific applicable requirements of Owner's and Contractor's safety programs of which Engineer has been informed.

## ARTICLE 11 — CHANGES TO THE CONTRACT

11.01 Amending and Supplementing the Contract

A. The Contract may be amended or supplemented by a Change Order, a Work Change Directive, or a Field Order.

B. If an amendment or supplement to the Contract includes a change in the Contract Price or the Contract Times, such amendment or supplement must be set forth in a Change Order.

C. All changes to the Contract that involve (1) the performance or acceptability of the Work, (2) the design (as set forth in the Drawings, Specifications, or otherwise), or (3) other engineering or technical matters, must be supported by Engineer's recommendation. Owner and Contractor may amend other terms and conditions of the Contract without the recommendation of the Engineer.

11.02 Change Orders

A. Owner and Contractor shall execute appropriate Change Orders covering:
   1. Changes in Contract Price or Contract Times which are agreed to by the parties, including any undisputed sum or amount of time for Work actually performed in accordance with a Work Change Directive;
   2. Changes in Contract Price resulting from an Owner set-off, unless Contractor has duly contested such set-off;
   3. Changes in the Work which are: (a) ordered by Owner pursuant to Paragraph 11.05, (b) required because of Owner's acceptance of defective Work under Paragraph 14.04 or Owner's correction of defective Work under Paragraph 14.07, or (c) agreed to by the parties, subject to the need for Engineer's recommendation if the change in the Work involves the design (as set forth in the Drawings, Specifications, or otherwise) or other engineering or technical matters; and
   4. Changes that embody the substance of any final and binding results under: Paragraph 11.03.B, resolving the impact of a Work Change Directive; Paragraph 11.09, concerning Change Proposals; Article 12, Claims; Paragraph 13.02.D, final adjustments resulting from allowances; Paragraph 13.03.D, final adjustments relating to determination of quantities for Unit Price Work; and similar provisions.

B. If Owner or Contractor refuses to execute a Change Order that is required to be executed under the terms of Paragraph 11.02.A, it will be deemed to be of full force and effect, as if fully executed.

11.03 Work Change Directives

A. A Work Change Directive will not change the Contract Price or the Contract Times but is evidence that the parties expect that the modification ordered or documented by a Work Change Directive will be incorporated in a subsequently issued Change Order, following negotiations by the parties as to the Work Change Directive's effect, if any, on the Contract Price and Contract Times; or, if negotiations are unsuccessful, by a determination under the terms of the Contract Documents governing adjustments, expressly including Paragraph 11.07 regarding change of Contract Price.

B. If Owner has issued a Work Change Directive and:
   1. Contractor believes that an adjustment in Contract Times or Contract Price is necessary, then Contractor shall submit any Change Proposal seeking such an adjustment no later than 30 days after the completion of the Work set out in the Work Change Directive.
   2. Owner believes that an adjustment in Contract Times or Contract Price is necessary, then Owner shall submit any Claim seeking such an adjustment no later than 60 days after issuance of the Work Change Directive.

11.04 Field Orders

A. Engineer may authorize minor changes in the Work if the changes do not involve an adjustment in the Contract Price or the Contract Times and are compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. Such changes will be accomplished by a Field Order and will be binding on Owner and also on Contractor, which shall perform the Work involved promptly.

B. If Contractor believes that a Field Order justifies an adjustment in the Contract Price or Contract Times, then before proceeding with the Work at issue, Contractor shall submit a Change Proposal as provided herein.

11.05 Owner-Authorized Changes in the Work

A. Without invalidating the Contract and without notice to any surety, Owner may, at any time or from time to time, order additions, deletions, or revisions in the Work. Changes involving the design (as set forth in the Drawings, Specifications, or otherwise) or other engineering or technical matters will be supported by Engineer's recommendation.

B. Such changes in the Work may be accomplished by a Change Order, if Owner and Contractor have agreed as to the effect, if any, of the changes on Contract Times or Contract Price; or by a Work Change Directive. Upon receipt of any such document, Contractor shall promptly proceed with the Work involved; or, in the case of a deletion in the Work, promptly cease construction activities with respect to such deleted Work. Added or revised Work must be performed under the applicable conditions of the Contract Documents.

C. Nothing in this Paragraph 11.05 obligates Contractor to undertake work that Contractor reasonably concludes cannot be performed in a manner consistent with Contractor's safety obligations under the Contract Documents or Laws and Regulations.

11.06 Unauthorized Changes in the Work

A. Contractor shall not be entitled to an increase in the Contract Price or an extension of the Contract Times with respect to any work performed that is not required by the Contract Documents, as amended, modified, or supplemented, except in the case of an emergency as provided in Paragraph 7.15 or in the case of uncovering Work as provided in Paragraph 14.05.C.2.

11.07 Change of Contract Price

A. The Contract Price may only be changed by a Change Order. Any Change Proposal for an adjustment in the Contract Price must comply with the provisions of Paragraph 11.09. Any Claim for an adjustment of Contract Price must comply with the provisions of Article 12.

B. An adjustment in the Contract Price will be determined as follows:
   1. Where the Work involved is covered by unit prices contained in the Contract Documents, then by application of such unit prices to the quantities of the items involved (subject to the provisions of Paragraph 13.03);
   2. Where the Work involved is not covered by unit prices contained in the Contract Documents, then by a mutually agreed lump sum (which may include an allowance for overhead and profit not necessarily in accordance with Paragraph 11.07.C.2); or
   3. Where the Work involved is not covered by unit prices contained in the Contract Documents and the parties do not reach mutual agreement to a lump sum, then on the basis of the Cost of the Work (determined as provided in Paragraph 13.01) plus a Contractor's fee for overhead and profit (determined as provided in Paragraph 11.07.C).

C. *Contractor's Fee*: When applicable, the Contractor's fee for overhead and profit will be determined as follows:
   1. A mutually acceptable fixed fee; or
   2. If a fixed fee is not agreed upon, then a fee based on the following percentages of the various portions of the Cost of the Work:
      a. For costs incurred under Paragraphs 13.01.B.1 and 13.01.B.2, the Contractor's fee will be 15 percent;
      b. For costs incurred under Paragraph 13.01.B.3, the Contractor's fee will be 5 percent;
      c. Where one or more tiers of subcontracts are on the basis of Cost of the Work plus a fee and no fixed fee is agreed upon, the intent of Paragraphs 11.07.C.2.a and 11.07.C.2.b is that the Contractor's fee will be based on: (1) a fee of 15 percent of the costs incurred under Paragraphs 13.01.B.1 and 13.01.B.2 by the Subcontractor that actually performs the Work, at whatever tier, and (2) with respect to Contractor itself and to any Subcontractors of a tier higher than that of the Subcontractor that actually performs the Work, a fee of 5 percent of the amount (fee plus underlying costs incurred) attributable to the next lower tier Subcontractor; provided, however, that for any such subcontracted Work the maximum total fee to be paid by Owner will be no greater than 27 percent of the costs incurred by the Subcontractor that actually performs the Work;
      d. No fee will be payable on the basis of costs itemized under Paragraphs 13.01.B.4, 13.01.B.5, and 13.01.C;
      e. The amount of credit to be allowed by Contractor to Owner for any change which results in a net decrease in Cost of the Work will be the amount of the actual net decrease in Cost of the Work and a deduction of an additional amount equal to 5 percent of such actual net decrease in Cost of the Work; and
      f. When both additions and credits are involved in any one change or Change Proposal, the adjustment in Contractor's fee will be computed by determining the sum of the costs in each of the cost categories in Paragraph 13.01.B (specifically, payroll costs, Paragraph 13.01.B.1; incorporated materials and equipment costs, Paragraph 13.01.B.2; Subcontract costs, Paragraph 13.01.B.3; special consultants costs, Paragraph 13.01.B.4; and other costs, Paragraph 13.01.B.5) and applying to each such cost category sum the appropriate fee from Paragraphs 11.07.C.2.a through 11.07.C.2.e, inclusive.

11.08 Change of Contract Times

A. The Contract Times may only be changed by a Change Order. Any Change Proposal for an adjustment in the Contract Times must comply with the provisions of Paragraph 11.09. Any Claim for an adjustment in the Contract Times must comply with the provisions of Article 12.

B. Delay, disruption, and interference in the Work, and any related changes in Contract Times, are addressed in and governed by Paragraph 4.05.

11.09 Change Proposals

A. *Purpose and Content*: Contractor shall submit a Change Proposal to Engineer to request an adjustment in the Contract Times or Contract Price; contest an initial decision by Engineer concerning the requirements of the Contract Documents or

relating to the acceptability of the Work under the Contract Documents; challenge a set-off against payment due; or seek other relief under the Contract. The Change Proposal will specify any proposed change in Contract Times or Contract Price, or other proposed relief, and explain the reason for the proposed change, with citations to any governing or applicable provisions of the Contract Documents. Each Change Proposal will address only one issue, or a set of closely related issues.

B. *Change Proposal Procedures*
   1. *Submittal*: Contractor shall submit each Change Proposal to Engineer within 30 days after the start of the event giving rise thereto, or after such initial decision.
   2. *Supporting Data*: The Contractor shall submit supporting data, including the proposed change in Contract Price or Contract Time (if any), to the Engineer and Owner within 15 days after the submittal of the Change Proposal.
      a. Change Proposals based on or related to delay, interruption, or interference must comply with the provisions of Paragraphs 4.05.D and 4.05.E.
      b. Change proposals related to a change of Contract Price must include full and detailed accounts of materials incorporated into the Work and labor and equipment used for the subject Work.

      The supporting data must be accompanied by a written statement that the supporting data are accurate and complete, and that any requested time or price adjustment is the entire adjustment to which Contractor believes it is entitled as a result of said event.
   3. *Engineer's Initial Review*: Engineer will advise Owner regarding the Change Proposal, and consider any comments or response from Owner regarding the Change Proposal. If in its discretion Engineer concludes that additional supporting data is needed before conducting a full review and making a decision regarding the Change Proposal, then Engineer may request that Contractor submit such additional supporting data by a date specified by Engineer, prior to Engineer beginning its full review of the Change Proposal.
   4. *Engineer's Full Review and Action on the Change Proposal*: Upon receipt of Contractor's supporting data (including any additional data requested by Engineer), Engineer will conduct a full review of each Change Proposal and, within 30 days after such receipt of the Contractor's supporting data, either approve the Change Proposal in whole, deny it in whole, or approve it in part and deny it in part. Such actions must be in writing, with a copy provided to Owner and Contractor. If Engineer does not take action on the Change Proposal within 30 days, then either Owner or Contractor may at any time thereafter submit a letter to the other party indicating that as a result of Engineer's inaction the Change Proposal is deemed denied, thereby commencing the time for appeal of the denial under Article 12.
   5. *Binding Decision*: Engineer's decision is final and binding upon Owner and Contractor, unless Owner or Contractor appeals the decision by filing a Claim under Article 12.

C. *Resolution of Certain Change Proposals*: If the Change Proposal does not involve the design (as set forth in the Drawings, Specifications, or otherwise), the acceptability of the Work, or other engineering or technical matters, then Engineer will notify the parties in writing that the Engineer is unable to resolve the Change Proposal. For purposes of further resolution of such a Change Proposal, such notice

will be deemed a denial, and Contractor may choose to seek resolution under the terms of Article 12.

D. *Post-Completion*: Contractor shall not submit any Change Proposals after Engineer issues a written recommendation of final payment pursuant to Paragraph 15.06.B.

11.10 Notification to Surety

A. If the provisions of any bond require notice to be given to a surety of any change affecting the general scope of the Work or the provisions of the Contract Documents (including, but not limited to, Contract Price or Contract Times), the giving of any such notice will be Contractor's responsibility. The amount of each applicable bond will be adjusted to reflect the effect of any such change.

## ARTICLE 12 — CLAIMS

12.01 Claims

A. *Claims Process*: The following disputes between Owner and Contractor are subject to the Claims process set forth in this article:
   1. Appeals by Owner or Contractor of Engineer's decisions regarding Change Proposals;
   2. Owner demands for adjustments in the Contract Price or Contract Times, or other relief under the Contract Documents;
   3. Disputes that Engineer has been unable to address because they do not involve the design (as set forth in the Drawings, Specifications, or otherwise), the acceptability of the Work, or other engineering or technical matters; and
   4. Subject to the waiver provisions of Paragraph 15.07, any dispute arising after Engineer has issued a written recommendation of final payment pursuant to Paragraph 15.06.B.

B. *Submittal of Claim*: The party submitting a Claim shall deliver it directly to the other party to the Contract promptly (but in no event later than 30 days) after the start of the event giving rise thereto; in the case of appeals regarding Change Proposals within 30 days of the decision under appeal. The party submitting the Claim shall also furnish a copy to the Engineer, for its information only. The responsibility to substantiate a Claim rests with the party making the Claim. In the case of a Claim by Contractor seeking an increase in the Contract Times or Contract Price, Contractor shall certify that the Claim is made in good faith, that the supporting data are accurate and complete, and that to the best of Contractor's knowledge and belief the amount of time or money requested accurately reflects the full amount to which Contractor is entitled.

C. *Review and Resolution*: The party receiving a Claim shall review it thoroughly, giving full consideration to its merits. The two parties shall seek to resolve the Claim through the exchange of information and direct negotiations. The parties may extend the time for resolving the Claim by mutual agreement. All actions taken on a Claim will be stated in writing and submitted to the other party, with a copy to Engineer.

D. *Mediation*
   1. At any time after initiation of a Claim, Owner and Contractor may mutually agree to mediation of the underlying dispute. The agreement to mediate will stay the Claim submittal and response process.

2. If Owner and Contractor agree to mediation, then after 60 days from such agreement, either Owner or Contractor may unilaterally terminate the mediation process, and the Claim submittal and decision process will resume as of the date of the termination. If the mediation proceeds but is unsuccessful in resolving the dispute, the Claim submittal and decision process will resume as of the date of the conclusion of the mediation, as determined by the mediator.
3. Owner and Contractor shall each pay one-half of the mediator's fees and costs.

E. *Partial Approval*: If the party receiving a Claim approves the Claim in part and denies it in part, such action will be final and binding unless within 30 days of such action the other party invokes the procedure set forth in Article 17 for final resolution of disputes.

F. *Denial of Claim*: If efforts to resolve a Claim are not successful, the party receiving the Claim may deny it by giving written notice of denial to the other party. If the receiving party does not take action on the Claim within 90 days, then either Owner or Contractor may at any time thereafter submit a letter to the other party indicating that as a result of the inaction, the Claim is deemed denied, thereby commencing the time for appeal of the denial. A denial of the Claim will be final and binding unless within 30 days of the denial the other party invokes the procedure set forth in Article 17 for the final resolution of disputes.

G. *Final and Binding Results*: If the parties reach a mutual agreement regarding a Claim, whether through approval of the Claim, direct negotiations, mediation, or otherwise; or if a Claim is approved in part and denied in part, or denied in full, and such actions become final and binding; then the results of the agreement or action on the Claim will be incorporated in a Change Order or other written document to the extent they affect the Contract, including the Work, the Contract Times, or the Contract Price.

## ARTICLE 13 — COST OF THE WORK; ALLOWANCES; UNIT PRICE WORK

13.01 Cost of the Work

A. *Purposes for Determination of Cost of the Work*: The term Cost of the Work means the sum of all costs necessary for the proper performance of the Work at issue, as further defined below. The provisions of this Paragraph 13.01 are used for two distinct purposes:
1. To determine Cost of the Work when Cost of the Work is a component of the Contract Price, under cost-plus-fee, time-and-materials, or other cost-based terms; or
2. When needed to determine the value of a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price. When the value of any such adjustment is determined on the basis of Cost of the Work, Contractor is entitled only to those additional or incremental costs required because of the change in the Work or because of the event giving rise to the adjustment.

B. *Costs Included*: Except as otherwise may be agreed to in writing by Owner, costs included in the Cost of the Work will be in amounts no higher than those commonly incurred in the locality of the Project, will not include any of the costs itemized in Paragraph 13.01.C, and will include only the following items:
1. Payroll costs for employees in the direct employ of Contractor in the performance of the Work under schedules of job classifications agreed upon by Owner and Contractor in advance of the subject Work. Such employees

include, without limitation, superintendents, foremen, safety managers, safety representatives, and other personnel employed full time on the Work. Payroll costs for employees not employed full time on the Work will be apportioned on the basis of their time spent on the Work. Payroll costs include, but are not limited to, salaries and wages plus the cost of fringe benefits, which include social security contributions, unemployment, excise, and payroll taxes, workers' compensation, health and retirement benefits, sick leave, and vacation and holiday pay applicable thereto. The expenses of performing Work outside of regular working hours, on Saturday, Sunday, or legal holidays, will be included in the above to the extent authorized by Owner.

2. Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof, and Suppliers' field services required in connection therewith. All cash discounts accrue to Contractor unless Owner deposits funds with Contractor with which to make payments, in which case the cash discounts will accrue to Owner. All trade discounts, rebates, and refunds and returns from sale of surplus materials and equipment will accrue to Owner, and Contractor shall make provisions so that they may be obtained.
3. Payments made by Contractor to Subcontractors for Work performed by Subcontractors. If required by Owner, Contractor shall obtain competitive bids from subcontractors acceptable to Owner and Contractor and shall deliver such bids to Owner, which will then determine, with the advice of Engineer, which bids, if any, will be acceptable. If any subcontract provides that the Subcontractor is to be paid on the basis of Cost of the Work plus a fee, the Subcontractor's Cost of the Work and fee will be determined in the same manner as Contractor's Cost of the Work and fee as provided in this Paragraph 13.01.
4. Costs of special consultants (including but not limited to engineers, architects, testing laboratories, surveyors, attorneys, and accountants) employed or retained for services specifically related to the Work.
5. Other costs consisting of the following:
    a. The proportion of necessary transportation, travel, and subsistence expenses of Contractor's employees incurred in discharge of duties connected with the Work.
    b. Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office, and temporary facilities at the Site, which are consumed in the performance of the Work, and cost, less market value, of such items used but not consumed which remain the property of Contractor.
        1) In establishing included costs for materials such as scaffolding, plating, or sheeting, consideration will be given to the actual or the estimated life of the material for use on other projects; or rental rates may be established on the basis of purchase or salvage value of such items, whichever is less. Contractor will not be eligible for compensation for such items in an amount that exceeds the purchase cost of such item.
    c. *Construction Equipment Rental*
        1) Rentals of all construction equipment and machinery, and the parts thereof, in accordance with rental agreements approved by Owner as to price (including any surcharge or special rates applicable to overtime use of the construction equipment or machinery), and the costs of transportation, loading, unloading, assembly, dismantling, and

removal thereof. All such costs will be in accordance with the terms of said rental agreements. The rental of any such equipment, machinery, or parts must cease when the use thereof is no longer necessary for the Work.

2) Costs for equipment and machinery owned by Contractor or a Contractor-related entity will be paid at a rate shown for such equipment in the equipment rental rate book specified in the Supplementary Conditions. An hourly rate will be computed by dividing the monthly rates by 176. These computed rates will include all operating costs.

3) With respect to Work that is the result of a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price ("changed Work"), included costs will be based on the time the equipment or machinery is in use on the changed Work and the costs of transportation, loading, unloading, assembly, dismantling, and removal when directly attributable to the changed Work. The cost of any such equipment or machinery, or parts thereof, must cease to accrue when the use thereof is no longer necessary for the changed Work.

d. Sales, consumer, use, and other similar taxes related to the Work, and for which Contractor is liable, as imposed by Laws and Regulations.

e. Deposits lost for causes other than negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, and royalty payments and fees for permits and licenses.

f. Losses and damages (and related expenses) caused by damage to the Work, not compensated by insurance or otherwise, sustained by Contractor in connection with the performance of the Work (except losses and damages within the deductible amounts of builder's risk or other property insurance established in accordance with Paragraph 6.04), provided such losses and damages have resulted from causes other than the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable. Such losses include settlements made with the written consent and approval of Owner. No such losses, damages, and expenses will be included in the Cost of the Work for the purpose of determining Contractor's fee.

g. The cost of utilities, fuel, and sanitary facilities at the Site.

h. Minor expenses such as communication service at the Site, express and courier services, and similar petty cash items in connection with the Work.

i. The costs of premiums for all bonds and insurance that Contractor is required by the Contract Documents to purchase and maintain.

C. *Costs Excluded*: The term Cost of the Work does not include any of the following items:

1. Payroll costs and other compensation of Contractor's officers, executives, principals, general managers, engineers, architects, estimators, attorneys, auditors, accountants, purchasing and contracting agents, expediters, timekeepers, clerks, and other personnel employed by Contractor, whether at the Site or in Contractor's principal or branch office for general administration of the Work and not specifically included in the agreed upon schedule of job classifications referred to in Paragraph 13.01.B.1 or specifically covered by

Paragraph 13.01.B.4. The payroll costs and other compensation excluded here are to be considered administrative costs covered by the Contractor's fee.

2. The cost of purchasing, renting, or furnishing small tools and hand tools.
3. Expenses of Contractor's principal and branch offices other than Contractor's office at the Site.
4. Any part of Contractor's capital expenses, including interest on Contractor's capital employed for the Work and charges against Contractor for delinquent payments.
5. Costs due to the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, including but not limited to, the correction of defective Work, disposal of materials or equipment wrongly supplied, and making good any damage to property.
6. Expenses incurred in preparing and advancing Claims.
7. Other overhead or general expense costs of any kind and the costs of any item not specifically and expressly included in Paragraph 13.01.B.

D. *Contractor's Fee*

1. When the Work as a whole is performed on the basis of cost-plus-a-fee, then:
   a. Contractor's fee for the Work set forth in the Contract Documents as of the Effective Date of the Contract will be determined as set forth in the Agreement.
   b. for any Work covered by a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price on the basis of Cost of the Work, Contractor's fee will be determined as follows:
      1) When the fee for the Work as a whole is a percentage of the Cost of the Work, the fee will automatically adjust as the Cost of the Work changes.
      2) When the fee for the Work as a whole is a fixed fee, the fee for any additions or deletions will be determined in accordance with Paragraph 11.07.C.2.
2. When the Work as a whole is performed on the basis of a stipulated sum, or any other basis other than cost-plus-a-fee, then Contractor's fee for any Work covered by a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price on the basis of Cost of the Work will be determined in accordance with Paragraph 11.07.C.2.

E. *Documentation and Audit*: Whenever the Cost of the Work for any purpose is to be determined pursuant to this Article 13, Contractor and pertinent Subcontractors will establish and maintain records of the costs in accordance with generally accepted accounting practices. Subject to prior written notice, Owner will be afforded reasonable access, during normal business hours, to all Contractor's accounts, records, books, correspondence, instructions, drawings, receipts, vouchers, memoranda, and similar data relating to the Cost of the Work and Contractor's fee. Contractor shall preserve all such documents for a period of three years after the final payment by Owner. Pertinent Subcontractors will afford such access to Owner, and preserve such documents, to the same extent required of Contractor.

13.02 Allowances

A. It is understood that Contractor has included in the Contract Price all allowances so named in the Contract Documents and shall cause the Work so covered to be

performed for such sums and by such persons or entities as may be acceptable to Owner and Engineer.

B. *Cash Allowances*: Contractor agrees that:
   1. the cash allowances include the cost to Contractor (less any applicable trade discounts) of materials and equipment required by the allowances to be delivered at the Site, and all applicable taxes; and
   2. Contractor's costs for unloading and handling on the Site, labor, installation, overhead, profit, and other expenses contemplated for the cash allowances have been included in the Contract Price and not in the allowances, and no demand for additional payment for any of the foregoing will be valid.

C. *Owner's Contingency Allowance*: Contractor agrees that an Owner's contingency allowance, if any, is for the sole use of Owner to cover unanticipated costs.

D. Prior to final payment, an appropriate Change Order will be issued as recommended by Engineer to reflect actual amounts due Contractor for Work covered by allowances, and the Contract Price will be correspondingly adjusted.

13.03 Unit Price Work

A. Where the Contract Documents provide that all or part of the Work is to be Unit Price Work, initially the Contract Price will be deemed to include for all Unit Price Work an amount equal to the sum of the unit price for each separately identified item of Unit Price Work times the estimated quantity of each item as indicated in the Agreement.

B. The estimated quantities of items of Unit Price Work are not guaranteed and are solely for the purpose of comparison of Bids and determining an initial Contract Price. Payments to Contractor for Unit Price Work will be based on actual quantities.

C. Each unit price will be deemed to include an amount considered by Contractor to be adequate to cover Contractor's overhead and profit for each separately identified item.

D. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor. Engineer will review with Contractor the Engineer's preliminary determinations on such matters before rendering a written decision thereon (by recommendation of an Application for Payment or otherwise). Engineer's written decision thereon will be final and binding (except as modified by Engineer to reflect changed factual conditions or more accurate data) upon Owner and Contractor, and the final adjustment of Contract Price will be set forth in a Change Order, subject to the provisions of the following paragraph.

*E. Adjustments in Unit Price*
   1. Contractor or Owner shall be entitled to an adjustment in the unit price with respect to an item of Unit Price Work if:
      a. the quantity of the item of Unit Price Work performed by Contractor differs materially and significantly from the estimated quantity of such item indicated in the Agreement; and
      b. Contractor's unit costs to perform the item of Unit Price Work have changed materially and significantly as a result of the quantity change.
   2. The adjustment in unit price will account for and be coordinated with any related changes in quantities of other items of Work, and in Contractor's costs to

perform such other Work, such that the resulting overall change in Contract Price is equitable to Owner and Contractor.

3. Adjusted unit prices will apply to all units of that item.

## ARTICLE 14 — TESTS AND INSPECTIONS; CORRECTION, REMOVAL, OR ACCEPTANCE OF DEFECTIVE WORK

14.01 Access to Work

A. Owner, Engineer, their consultants and other representatives and personnel of Owner, independent testing laboratories, and authorities having jurisdiction have access to the Site and the Work at reasonable times for their observation, inspection, and testing. Contractor shall provide them proper and safe conditions for such access and advise them of Contractor's safety procedures and programs so that they may comply with such procedures and programs as applicable.

14.02 Tests, Inspections, and Approvals

A. Contractor shall give Engineer timely notice of readiness of the Work (or specific parts thereof) for all required inspections and tests, and shall cooperate with inspection and testing personnel to facilitate required inspections and tests.

B. Owner shall retain and pay for the services of an independent inspector, testing laboratory, or other qualified individual or entity to perform all inspections and tests expressly required by the Contract Documents to be furnished and paid for by Owner, except that costs incurred in connection with tests or inspections of covered Work will be governed by the provisions of Paragraph 14.05.

C. If Laws or Regulations of any public body having jurisdiction require any Work (or part thereof) specifically to be inspected, tested, or approved by an employee or other representative of such public body, Contractor shall assume full responsibility for arranging and obtaining such inspections, tests, or approvals, pay all costs in connection therewith, and furnish Engineer the required certificates of inspection or approval.

D. Contractor shall be responsible for arranging, obtaining, and paying for all inspections and tests required:

1. by the Contract Documents, unless the Contract Documents expressly allocate responsibility for a specific inspection or test to Owner;
2. to attain Owner's and Engineer's acceptance of materials or equipment to be incorporated in the Work;
3. by manufacturers of equipment furnished under the Contract Documents;
4. for testing, adjusting, and balancing of mechanical, electrical, and other equipment to be incorporated into the Work; and
5. for acceptance of materials, mix designs, or equipment submitted for approval prior to Contractor's purchase thereof for incorporation in the Work.

Such inspections and tests will be performed by independent inspectors, testing laboratories, or other qualified individuals or entities acceptable to Owner and Engineer.

E. If the Contract Documents require the Work (or part thereof) to be approved by Owner, Engineer, or another designated individual or entity, then Contractor shall assume full responsibility for arranging and obtaining such approvals.

F. If any Work (or the work of others) that is to be inspected, tested, or approved is covered by Contractor without written concurrence of Engineer, Contractor shall, if requested by Engineer, uncover such Work for observation. Such uncovering will be at Contractor's expense unless Contractor had given Engineer timely notice of Contractor's intention to cover the same and Engineer had not acted with reasonable promptness in response to such notice.

14.03 Defective Work

A. *Contractor's Obligation*: It is Contractor's obligation to assure that the Work is not defective.

B. *Engineer's Authority*: Engineer has the authority to determine whether Work is defective, and to reject defective Work.

C. *Notice of Defects*: Prompt written notice of all defective Work of which Owner or Engineer has actual knowledge will be given to Contractor.

D. *Correction, or Removal and Replacement*: Promptly after receipt of written notice of defective Work, Contractor shall correct all such defective Work, whether or not fabricated, installed, or completed, or, if Engineer has rejected the defective Work, remove it from the Project and replace it with Work that is not defective.

E. *Preservation of Warranties*: When correcting defective Work, Contractor shall take no action that would void or otherwise impair Owner's special warranty and guarantee, if any, on said Work.

F. *Costs and Damages*: In addition to its correction, removal, and replacement obligations with respect to defective Work, Contractor shall pay all claims, costs, losses, and damages arising out of or relating to defective Work, including but not limited to the cost of the inspection, testing, correction, removal, replacement, or reconstruction of such defective Work, fines levied against Owner by governmental authorities because the Work is defective, and the costs of repair or replacement of work of others resulting from defective Work. Prior to final payment, if Owner and Contractor are unable to agree as to the measure of such claims, costs, losses, and damages resulting from defective Work, then Owner may impose a reasonable set-off against payments due under Article 15.

14.04 Acceptance of Defective Work

A. If, instead of requiring correction or removal and replacement of defective Work, Owner prefers to accept it, Owner may do so (subject, if such acceptance occurs prior to final payment, to Engineer's confirmation that such acceptance is in general accord with the design intent and applicable engineering principles, and will not endanger public safety). Contractor shall pay all claims, costs, losses, and damages attributable to Owner's evaluation of and determination to accept such defective Work (such costs to be approved by Engineer as to reasonableness), and for the diminished value of the Work to the extent not otherwise paid by Contractor. If any such acceptance occurs prior to final payment, the necessary revisions in the Contract Documents with respect to the Work will be incorporated in a Change Order. If the parties are unable to agree as to the decrease in the Contract Price, reflecting the diminished value of Work so accepted, then Owner may impose a reasonable set-off against payments due under Article 15. If the acceptance of defective Work occurs after final payment, Contractor shall pay an appropriate amount to Owner.

14.05 Uncovering Work

A. Engineer has the authority to require additional inspection or testing of the Work, whether or not the Work is fabricated, installed, or completed.

B. If any Work is covered contrary to the written request of Engineer, then Contractor shall, if requested by Engineer, uncover such Work for Engineer's observation, and then replace the covering, all at Contractor's expense.

C. If Engineer considers it necessary or advisable that covered Work be observed by Engineer or inspected or tested by others, then Contractor, at Engineer's request, shall uncover, expose, or otherwise make available for observation, inspection, or testing as Engineer may require, that portion of the Work in question, and provide all necessary labor, material, and equipment.

1. If it is found that the uncovered Work is defective, Contractor shall be responsible for all claims, costs, losses, and damages arising out of or relating to such uncovering, exposure, observation, inspection, and testing, and of satisfactory replacement or reconstruction (including but not limited to all costs of repair or replacement of work of others); and pending Contractor's full discharge of this responsibility the Owner shall be entitled to impose a reasonable set-off against payments due under Article 15.
2. If the uncovered Work is not found to be defective, Contractor shall be allowed an increase in the Contract Price or an extension of the Contract Times, directly attributable to such uncovering, exposure, observation, inspection, testing, replacement, and reconstruction. If the parties are unable to agree as to the amount or extent thereof, then Contractor may submit a Change Proposal within 30 days of the determination that the Work is not defective.

14.06 Owner May Stop the Work

A. If the Work is defective, or Contractor fails to supply sufficient skilled workers or suitable materials or equipment, or fails to perform the Work in such a way that the completed Work will conform to the Contract Documents, then Owner may order Contractor to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, this right of Owner to stop the Work will not give rise to any duty on the part of Owner to exercise this right for the benefit of Contractor, any Subcontractor, any Supplier, any other individual or entity, or any surety for, or employee or agent of any of them.

14.07 Owner May Correct Defective Work

A. If Contractor fails within a reasonable time after written notice from Engineer to correct defective Work, or to remove and replace defective Work as required by Engineer, then Owner may, after 7 days' written notice to Contractor, correct or remedy any such deficiency.

B. In exercising the rights and remedies under this Paragraph 14.07, Owner shall proceed expeditiously. In connection with such corrective or remedial action, Owner may exclude Contractor from all or part of the Site, take possession of all or part of the Work and suspend Contractor's services related thereto, and incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere. Contractor shall allow Owner, Owner's representatives, agents and employees, Owner's other contractors, and Engineer and Engineer's consultants access to the Site to enable Owner to exercise the rights and remedies under this paragraph.

C. All claims, costs, losses, and damages incurred or sustained by Owner in exercising the rights and remedies under this Paragraph 14.07 will be charged against Contractor as set-offs against payments due under Article 15. Such claims, costs, losses and damages will include but not be limited to all costs of repair, or replacement of work of others destroyed or damaged by correction, removal, or replacement of Contractor's defective Work.

D. Contractor shall not be allowed an extension of the Contract Times because of any delay in the performance of the Work attributable to the exercise by Owner of Owner's rights and remedies under this Paragraph 14.07.

## ARTICLE 15 — PAYMENTS TO CONTRACTOR; SET-OFFS; COMPLETION; CORRECTION PERIOD

15.01 Progress Payments

A. *Basis for Progress Payments*: The Schedule of Values established as provided in Article 2 will serve as the basis for progress payments and will be incorporated into a form of Application for Payment acceptable to Engineer. Progress payments for Unit Price Work will be based on the number of units completed during the pay period, as determined under the provisions of Paragraph 13.03. Progress payments for cost-based Work will be based on Cost of the Work completed by Contractor during the pay period.

B. *Applications for Payments*
   1. At least 20 days before the date established in the Agreement for each progress payment (but not more often than once a month), Contractor shall submit to Engineer for review an Application for Payment filled out and signed by Contractor covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents.
   2. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at the Site or at another location agreed to in writing, the Application for Payment must also be accompanied by: (a) a bill of sale, invoice, copies of subcontract or purchase order payments, or other documentation establishing full payment by Contractor for the materials and equipment; (b) at Owner's request, documentation warranting that Owner has received the materials and equipment free and clear of all Liens; and (c) evidence that the materials and equipment are covered by appropriate property insurance, a warehouse bond, or other arrangements to protect Owner's interest therein, all of which must be satisfactory to Owner.
   3. Beginning with the second Application for Payment, each Application must include an affidavit of Contractor stating that all previous progress payments received by Contractor have been applied to discharge Contractor's legitimate obligations associated with prior Applications for Payment.
   4. The amount of retainage with respect to progress payments will be as stipulated in the Agreement.

*C. Review of Applications*
   1. Engineer will, within 10 days after receipt of each Application for Payment, including each resubmittal, either indicate in writing a recommendation of payment and present the Application to Owner, or return the Application to Contractor indicating in writing Engineer's reasons for refusing to recommend

payment. In the latter case, Contractor may make the necessary corrections and resubmit the Application.

2. Engineer's recommendation of any payment requested in an Application for Payment will constitute a representation by Engineer to Owner, based on Engineer's observations of the executed Work as an experienced and qualified design professional, and on Engineer's review of the Application for Payment and the accompanying data and schedules, that to the best of Engineer's knowledge, information and belief:
    a. the Work has progressed to the point indicated;
    b. the quality of the Work is generally in accordance with the Contract Documents (subject to an evaluation of the Work as a functioning whole prior to or upon Substantial Completion, the results of any subsequent tests called for in the Contract Documents, a final determination of quantities and classifications for Unit Price Work under Paragraph 13.03, and any other qualifications stated in the recommendation); and
    c. the conditions precedent to Contractor's being entitled to such payment appear to have been fulfilled in so far as it is Engineer's responsibility to observe the Work.
3. By recommending any such payment Engineer will not thereby be deemed to have represented that:
    a. inspections made to check the quality or the quantity of the Work as it has been performed have been exhaustive, extended to every aspect of the Work in progress, or involved detailed inspections of the Work beyond the responsibilities specifically assigned to Engineer in the Contract; or
    b. there may not be other matters or issues between the parties that might entitle Contractor to be paid additionally by Owner or entitle Owner to withhold payment to Contractor.
4. Neither Engineer's review of Contractor's Work for the purposes of recommending payments nor Engineer's recommendation of any payment, including final payment, will impose responsibility on Engineer:
    a. to supervise, direct, or control the Work;
    b. for the means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto;
    c. for Contractor's failure to comply with Laws and Regulations applicable to Contractor's performance of the Work;
    d. to make any examination to ascertain how or for what purposes Contractor has used the money paid by Owner; or
    e. to determine that title to any of the Work, materials, or equipment has passed to Owner free and clear of any Liens.
5. Engineer may refuse to recommend the whole or any part of any payment if, in Engineer's opinion, it would be incorrect to make the representations to Owner stated in Paragraph 15.01.C.2.
6. Engineer will recommend reductions in payment (set-offs) necessary in Engineer's opinion to protect Owner from loss because:
    a. the Work is defective, requiring correction or replacement;
    b. the Contract Price has been reduced by Change Orders;
    c. Owner has been required to correct defective Work in accordance with Paragraph 14.07, or has accepted defective Work pursuant to Paragraph 14.04;
    d. Owner has been required to remove or remediate a Hazardous Environmental Condition for which Contractor is responsible; or

e. Engineer has actual knowledge of the occurrence of any of the events that would constitute a default by Contractor and therefore justify termination for cause under the Contract Documents.

D. *Payment Becomes Due*

1. Ten days after presentation of the Application for Payment to Owner with Engineer's recommendation, the amount recommended (subject to any Owner set-offs) will become due, and when due will be paid by Owner to Contractor.

*E. Reductions in Payment by Owner*

1. In addition to any reductions in payment (set-offs) recommended by Engineer, Owner is entitled to impose a set-off against payment based on any of the following:
   a. Claims have been made against Owner based on Contractor's conduct in the performance or furnishing of the Work, or Owner has incurred costs, losses, or damages resulting from Contractor's conduct in the performance or furnishing of the Work, including but not limited to claims, costs, losses, or damages from workplace injuries, adjacent property damage, non-compliance with Laws and Regulations, and patent infringement;
   b. Contractor has failed to take reasonable and customary measures to avoid damage, delay, disruption, and interference with other work at or adjacent to the Site;
   c. Contractor has failed to provide and maintain required bonds or insurance;
   d. Owner has been required to remove or remediate a Hazardous Environmental Condition for which Contractor is responsible;
   e. Owner has incurred extra charges or engineering costs related to submittal reviews, evaluations of proposed substitutes, tests and inspections, or return visits to manufacturing or assembly facilities;
   f. The Work is defective, requiring correction or replacement;
   g. Owner has been required to correct defective Work in accordance with Paragraph 14.07, or has accepted defective Work pursuant to Paragraph 14.04;
   h. The Contract Price has been reduced by Change Orders;
   i. An event has occurred that would constitute a default by Contractor and therefore justify a termination for cause;
   j. Liquidated or other damages have accrued as a result of Contractor's failure to achieve Milestones, Substantial Completion, or final completion of the Work;
   k. Liens have been filed in connection with the Work, except where Contractor has delivered a specific bond satisfactory to Owner to secure the satisfaction and discharge of such Liens; or
   l. Other items entitle Owner to a set-off against the amount recommended.
2. If Owner imposes any set-off against payment, whether based on its own knowledge or on the written recommendations of Engineer, Owner will give Contractor immediate written notice (with a copy to Engineer) stating the reasons for such action and the specific amount of the reduction, and promptly pay Contractor any amount remaining after deduction of the amount so withheld. Owner shall promptly pay Contractor the amount so withheld, or any adjustment thereto agreed to by Owner and Contractor, if Contractor remedies the reasons for such action. The reduction imposed will be binding on Contractor unless it duly submits a Change Proposal contesting the reduction.

3. Upon a subsequent determination that Owner's refusal of payment was not justified, the amount wrongfully withheld will be treated as an amount due as determined by Paragraph 15.01.D.1 and subject to interest as provided in the Agreement.

15.02 Contractor's Warranty of Title

A. Contractor warrants and guarantees that title to all Work, materials, and equipment furnished under the Contract will pass to Owner free and clear of (1) all Liens and other title defects, and (2) all patent, licensing, copyright, or royalty obligations, no later than 7 days after the time of payment by Owner.

15.03 Substantial Completion

A. When Contractor considers the entire Work ready for its intended use Contractor shall notify Owner and Engineer in writing that the entire Work is substantially complete and request that Engineer issue a certificate of Substantial Completion. Contractor shall at the same time submit to Owner and Engineer an initial draft of punch list items to be completed or corrected before final payment.

B. Promptly after Contractor's notification, Owner, Contractor, and Engineer shall make an inspection of the Work to determine the status of completion. If Engineer does not consider the Work substantially complete, Engineer will notify Contractor in writing giving the reasons therefor.

C. If Engineer considers the Work substantially complete, Engineer will deliver to Owner a preliminary certificate of Substantial Completion which will fix the date of Substantial Completion. Engineer shall attach to the certificate a punch list of items to be completed or corrected before final payment. Owner shall have 7 days after receipt of the preliminary certificate during which to make written objection to Engineer as to any provisions of the certificate or attached punch list. If, after considering the objections to the provisions of the preliminary certificate, Engineer concludes that the Work is not substantially complete, Engineer will, within 14 days after submission of the preliminary certificate to Owner, notify Contractor in writing that the Work is not substantially complete, stating the reasons therefor. If Owner does not object to the provisions of the certificate, or if despite consideration of Owner's objections Engineer concludes that the Work is substantially complete, then Engineer will, within said 14 days, execute and deliver to Owner and Contractor a final certificate of Substantial Completion (with a revised punch list of items to be completed or corrected) reflecting such changes from the preliminary certificate as Engineer believes justified after consideration of any objections from Owner.

D. At the time of receipt of the preliminary certificate of Substantial Completion, Owner and Contractor will confer regarding Owner's use or occupancy of the Work following Substantial Completion, review the builder's risk insurance policy with respect to the end of the builder's risk coverage, and confirm the transition to coverage of the Work under a permanent property insurance policy held by Owner. Unless Owner and Contractor agree otherwise in writing, Owner shall bear responsibility for security, operation, protection of the Work, property insurance, maintenance, heat, and utilities upon Owner's use or occupancy of the Work.

E. After Substantial Completion the Contractor shall promptly begin work on the punch list of items to be completed or corrected prior to final payment. In appropriate cases

Contractor may submit monthly Applications for Payment for completed punch list items, following the progress payment procedures set forth above.

F. Owner shall have the right to exclude Contractor from the Site after the date of Substantial Completion subject to allowing Contractor reasonable access to remove its property and complete or correct items on the punch list.

15.04 Partial Use or Occupancy

A. Prior to Substantial Completion of all the Work, Owner may use or occupy any substantially completed part of the Work which has specifically been identified in the Contract Documents, or which Owner, Engineer, and Contractor agree constitutes a separately functioning and usable part of the Work that can be used by Owner for its intended purpose without significant interference with Contractor's performance of the remainder of the Work, subject to the following conditions:

1. At any time, Owner may request in writing that Contractor permit Owner to use or occupy any such part of the Work that Owner believes to be substantially complete. If and when Contractor agrees that such part of the Work is substantially complete, Contractor, Owner, and Engineer will follow the procedures of Paragraph 15.03.A through 15.03.E for that part of the Work.
2. At any time, Contractor may notify Owner and Engineer in writing that Contractor considers any such part of the Work substantially complete and request Engineer to issue a certificate of Substantial Completion for that part of the Work.
3. Within a reasonable time after either such request, Owner, Contractor, and Engineer shall make an inspection of that part of the Work to determine its status of completion. If Engineer does not consider that part of the Work to be substantially complete, Engineer will notify Owner and Contractor in writing giving the reasons therefor. If Engineer considers that part of the Work to be substantially complete, the provisions of Paragraph 15.03 will apply with respect to certification of Substantial Completion of that part of the Work and the division of responsibility in respect thereof and access thereto.
4. No use or occupancy or separate operation of part of the Work may occur prior to compliance with the requirements of Paragraph 6.04 regarding builder's risk or other property insurance.

15.05 Final Inspection

A. Upon written notice from Contractor that the entire Work or an agreed portion thereof is complete, Engineer will promptly make a final inspection with Owner and Contractor and will notify Contractor in writing of all particulars in which this inspection reveals that the Work, or agreed portion thereof, is incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such Work or remedy such deficiencies.

15.06 Final Payment

*A. Application for Payment*

1. After Contractor has, in the opinion of Engineer, satisfactorily completed all corrections identified during the final inspection and has delivered, in accordance with the Contract Documents, all maintenance and operating instructions, schedules, guarantees, bonds, certificates or other evidence of insurance, certificates of inspection, annotated record documents (as provided in Paragraph 7.12), and other documents, Contractor may make application for final payment.

2. The final Application for Payment must be accompanied (except as previously delivered) by:
    a. all documentation called for in the Contract Documents;
    b. consent of the surety, if any, to final payment;
    c. satisfactory evidence that all title issues have been resolved such that title to all Work, materials, and equipment has passed to Owner free and clear of any Liens or other title defects, or will so pass upon final payment.
    d. a list of all duly pending Change Proposals and Claims; and
    e. complete and legally effective releases or waivers (satisfactory to Owner) of all Lien rights arising out of the Work, and of Liens filed in connection with the Work.
3. In lieu of the releases or waivers of Liens specified in Paragraph 15.06.A.2 and as approved by Owner, Contractor may furnish receipts or releases in full and an affidavit of Contractor that: (a) the releases and receipts include all labor, services, material, and equipment for which a Lien could be filed; and (b) all payrolls, material and equipment bills, and other indebtedness connected with the Work for which Owner might in any way be responsible, or which might in any way result in liens or other burdens on Owner's property, have been paid or otherwise satisfied. If any Subcontractor or Supplier fails to furnish such a release or receipt in full, Contractor may furnish a bond or other collateral satisfactory to Owner to indemnify Owner against any Lien, or Owner at its option may issue joint checks payable to Contractor and specified Subcontractors and Suppliers.

B. *Engineer's Review of Final Application and Recommendation of Payment*: If, on the basis of Engineer's observation of the Work during construction and final inspection, and Engineer's review of the final Application for Payment and accompanying documentation as required by the Contract Documents, Engineer is satisfied that the Work has been completed and Contractor's other obligations under the Contract have been fulfilled, Engineer will, within 10 days after receipt of the final Application for Payment, indicate in writing Engineer's recommendation of final payment and present the final Application for Payment to Owner for payment. Such recommendation will account for any set-offs against payment that are necessary in Engineer's opinion to protect Owner from loss for the reasons stated above with respect to progress payments. Otherwise, Engineer will return the Application for Payment to Contractor, indicating in writing the reasons for refusing to recommend final payment, in which case Contractor shall make the necessary corrections and resubmit the Application for Payment.

C. *Notice of Acceptability*: In support of its recommendation of payment of the final Application for Payment, Engineer will also give written notice to Owner and Contractor that the Work is acceptable, subject to stated limitations in the notice and to the provisions of Paragraph 15.07.

D. *Completion of Work*: The Work is complete (subject to surviving obligations) when it is ready for final payment as established by the Engineer's written recommendation of final payment and issuance of notice of the acceptability of the Work.

E. *Final Payment Becomes Due*: Upon receipt from Engineer of the final Application for Payment and accompanying documentation, Owner shall set off against the amount recommended by Engineer for final payment any further sum to which Owner is entitled, including but not limited to set-offs for liquidated damages and set-offs allowed under the provisions of this Contract with respect to progress payments.

Owner shall pay the resulting balance due to Contractor within 30 days of Owner's receipt of the final Application for Payment from Engineer.

15.07 Waiver of Claims

A. By making final payment, Owner waives its claim or right to liquidated damages or other damages for late completion by Contractor, except as set forth in an outstanding Claim, appeal under the provisions of Article 17, set-off, or express reservation of rights by Owner. Owner reserves all other claims or rights after final payment.

B. The acceptance of final payment by Contractor will constitute a waiver by Contractor of all claims and rights against Owner other than those pending matters that have been duly submitted as a Claim, or appealed under the provisions of Article 17.

15.08 Correction Period

A. If within one year after the date of Substantial Completion (or such longer period of time as may be prescribed by the Supplementary Conditions or the terms of any applicable special guarantee required by the Contract Documents), Owner gives Contractor written notice that any Work has been found to be defective, or that Contractor's repair of any damages to the Site or adjacent areas has been found to be defective, then after receipt of such notice of defect Contractor shall promptly, without cost to Owner and in accordance with Owner's written instructions:
   1. correct the defective repairs to the Site or such adjacent areas;
   2. correct such defective Work;
   3. remove the defective Work from the Project and replace it with Work that is not defective, if the defective Work has been rejected by Owner, and
   4. satisfactorily correct or repair or remove and replace any damage to other Work, to the work of others, or to other land or areas resulting from the corrective measures.

B. Owner shall give any such notice of defect within 60 days of the discovery that such Work or repairs is defective. If such notice is given within such 60 days but after the end of the correction period, the notice will be deemed a notice of defective Work under Paragraph 7.17.B.

C. If, after receipt of a notice of defect within 60 days and within the correction period, Contractor does not promptly comply with the terms of Owner's written instructions, or in an emergency where delay would cause serious risk of loss or damage, Owner may have the defective Work corrected or repaired or may have the rejected Work removed and replaced. Contractor shall pay all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or repair or such removal and replacement (including but not limited to all costs of repair or replacement of work of others). Contractor's failure to pay such costs, losses, and damages within 10 days of invoice from Owner will be deemed the start of an event giving rise to a Claim under Paragraph 12.01.B, such that any related Claim must be brought within 30 days of the failure to pay.

D. In special circumstances where a particular item of equipment is placed in continuous service before Substantial Completion of all the Work, the correction period for that item may start to run from an earlier date if so provided in the Specifications.

E. Where defective Work (and damage to other Work resulting therefrom) has been corrected or removed and replaced under this paragraph, the correction period hereunder with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactorily completed.

F. Contractor's obligations under this paragraph are in addition to all other obligations and warranties. The provisions of this paragraph are not to be construed as a substitute for, or a waiver of, the provisions of any applicable statute of limitation or repose.

## ARTICLE 16 — SUSPENSION OF WORK AND TERMINATION

16.01 Owner May Suspend Work

A. At any time and without cause, Owner may suspend the Work or any portion thereof for a period of not more than 90 consecutive days by written notice to Contractor and Engineer. Such notice will fix the date on which Work will be resumed. Contractor shall resume the Work on the date so fixed. Contractor shall be entitled to an adjustment in the Contract Price or an extension of the Contract Times directly attributable to any such suspension. Any Change Proposal seeking such adjustments must be submitted no later than 30 days after the date fixed for resumption of Work.

16.02 Owner May Terminate for Cause

A. The occurrence of any one or more of the following events will constitute a default by Contractor and justify termination for cause:
   1. Contractor's persistent failure to perform the Work in accordance with the Contract Documents (including, but not limited to, failure to supply sufficient skilled workers or suitable materials or equipment, or failure to adhere to the Progress Schedule);
   2. Failure of Contractor to perform or otherwise to comply with a material term of the Contract Documents;
   3. Contractor's disregard of Laws or Regulations of any public body having jurisdiction; or
   4. Contractor's repeated disregard of the authority of Owner or Engineer.

B. If one or more of the events identified in Paragraph 16.02.A occurs, then after giving Contractor (and any surety) 10 days' written notice that Owner is considering a declaration that Contractor is in default and termination of the Contract, Owner may proceed to:
   1. declare Contractor to be in default, and give Contractor (and any surety) written notice that the Contract is terminated; and
   2. enforce the rights available to Owner under any applicable performance bond.

C. Subject to the terms and operation of any applicable performance bond, if Owner has terminated the Contract for cause, Owner may exclude Contractor from the Site, take possession of the Work, incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere, and complete the Work as Owner may deem expedient.

D. Owner may not proceed with termination of the Contract under Paragraph 16.02.B if Contractor within 7 days of receipt of notice of intent to terminate begins to correct its failure to perform and proceeds diligently to cure such failure.

E. If Owner proceeds as provided in Paragraph 16.02.B, Contractor shall not be entitled to receive any further payment until the Work is completed. If the unpaid balance of the Contract Price exceeds the cost to complete the Work, including all related claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals) sustained by Owner, such excess will be paid to Contractor. If the cost to complete the Work including such related claims, costs, losses, and damages exceeds such unpaid balance, Contractor shall pay the difference to Owner. Such claims, costs, losses, and damages incurred by Owner will be reviewed by Engineer as to their reasonableness and, when so approved by Engineer, incorporated in a Change Order. When exercising any rights or remedies under this paragraph, Owner shall not be required to obtain the lowest price for the Work performed.

F. Where Contractor's services have been so terminated by Owner, the termination will not affect any rights or remedies of Owner against Contractor then existing or which may thereafter accrue, or any rights or remedies of Owner against Contractor or any surety under any payment bond or performance bond. Any retention or payment of money due Contractor by Owner will not release Contractor from liability.

G. If and to the extent that Contractor has provided a performance bond under the provisions of Paragraph 6.01.A, the provisions of that bond will govern over any inconsistent provisions of Paragraphs 16.02.B and 16.02.D.

16.03 Owner May Terminate for Convenience

A. Upon 7 days' written notice to Contractor and Engineer, Owner may, without cause and without prejudice to any other right or remedy of Owner, terminate the Contract. In such case, Contractor shall be paid for (without duplication of any items):
   1. completed and acceptable Work executed in accordance with the Contract Documents prior to the effective date of termination, including fair and reasonable sums for overhead and profit on such Work;
   2. expenses sustained prior to the effective date of termination in performing services and furnishing labor, materials, or equipment as required by the Contract Documents in connection with uncompleted Work, plus fair and reasonable sums for overhead and profit on such expenses; and
   3. other reasonable expenses directly attributable to termination, including costs incurred to prepare a termination for convenience cost proposal.

B. Contractor shall not be paid for any loss of anticipated profits or revenue, post-termination overhead costs, or other economic loss arising out of or resulting from such termination.

16.04 Contractor May Stop Work or Terminate

A. If, through no act or fault of Contractor, (1) the Work is suspended for more than 90 consecutive days by Owner or under an order of court or other public authority, or (2) Engineer fails to act on any Application for Payment within 30 days after it is submitted, or (3) Owner fails for 30 days to pay Contractor any sum finally determined to be due, then Contractor may, upon 7 days' written notice to Owner and Engineer, and provided Owner or Engineer do not remedy such suspension or failure within that time, terminate the contract and recover from Owner payment on the same terms as provided in Paragraph 16.03.

B. In lieu of terminating the Contract and without prejudice to any other right or remedy, if Engineer has failed to act on an Application for Payment within 30 days after it is

submitted, or Owner has failed for 30 days to pay Contractor any sum finally determined to be due, Contractor may, 7 days after written notice to Owner and Engineer, stop the Work until payment is made of all such amounts due Contractor, including interest thereon. The provisions of this paragraph are not intended to preclude Contractor from submitting a Change Proposal for an adjustment in Contract Price or Contract Times or otherwise for expenses or damage directly attributable to Contractor's stopping the Work as permitted by this paragraph.

## ARTICLE 17 — FINAL RESOLUTION OF DISPUTES

17.01 Methods and Procedures

A. *Disputes Subject to Final Resolution*: The following disputed matters are subject to final resolution under the provisions of this article:
   1. A timely appeal of an approval in part and denial in part of a Claim, or of a denial in full, pursuant to Article 12; and
   2. Disputes between Owner and Contractor concerning the Work, or obligations under the Contract Documents, that arise after final payment has been made.

B. *Final Resolution of Disputes*: For any dispute subject to resolution under this article, Owner or Contractor may:
   1. elect in writing to invoke the dispute resolution process provided for in the Supplementary Conditions;
   2. agree with the other party to submit the dispute to another dispute resolution process; or
   3. if no dispute resolution process is provided for in the Supplementary Conditions or mutually agreed to, give written notice to the other party of the intent to submit the dispute to a court of competent jurisdiction.

## ARTICLE 18 — MISCELLANEOUS

18.01 Giving Notice

A. Whenever any provision of the Contract requires the giving of written notice to Owner, Engineer, or Contractor, it will be deemed to have been validly given only if delivered:
   1. in person, by a commercial courier service or otherwise, to the recipient's place of business;
   2. by registered or certified mail, postage prepaid, to the recipient's place of business; or
   3. by e-mail to the recipient, with the words "Formal Notice" or similar in the e-mail's subject line.

18.02 Computation of Times

A. When any period of time is referred to in the Contract by days, it will be computed to exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day will be omitted from the computation.

18.03 Cumulative Remedies

A. The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto are in addition to, and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee, or by other provisions of the Contract. The provisions

of this paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty, obligation, right, and remedy to which they apply.

18.04 Limitation of Damages

A. With respect to any and all Change Proposals, Claims, disputes subject to final resolution, and other matters at issue, neither Owner nor Engineer, nor any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, shall be liable to Contractor for any claims, costs, losses, or damages sustained by Contractor on or in connection with any other project or anticipated project.

18.05 No Waiver

A. A party's non-enforcement of any provision will not constitute a waiver of that provision, nor will it affect the enforceability of that provision or of the remainder of this Contract.

18.06 Survival of Obligations

A. All representations, indemnifications, warranties, and guarantees made in, required by, or given in accordance with the Contract, as well as all continuing obligations indicated in the Contract, will survive final payment, completion, and acceptance of the Work or termination of the Contract or of the services of Contractor.

18.07 Controlling Law

A. This Contract is to be governed by the law of the state in which the Project is located.

18.08 Assignment of Contract

A. Unless expressly agreed to elsewhere in the Contract, no assignment by a party to this Contract of any rights under or interests in the Contract will be binding on the other party without the written consent of the party sought to be bound; and, specifically but without limitation, money that may become due and money that is due may not be assigned without such consent (except to the extent that the effect of this restriction may be limited by law), and unless specifically stated to the contrary in any written consent to an assignment, no assignment will release or discharge the assignor from any duty or responsibility under the Contract.

18.09 Successors and Assigns

A. Owner and Contractor each binds itself, its successors, assigns, and legal representatives to the other party hereto, its successors, assigns, and legal representatives in respect to all covenants, agreements, and obligations contained in the Contract Documents.

18.10 Headings

A. Article and paragraph headings are inserted for convenience only and do not constitute parts of these General Conditions.

END OF DOCUMENT

# DOCUMENT 00800

## SUPPLEMENTARY CONDITIONS

These Supplementary Conditions amend or supplement Document 00700 - General Conditions. All provisions, which are not so amended or supplemented, remain in full force and effect.

The terms used in these Supplementary Conditions will have the meanings indicated in the General Conditions. Additional terms used in these Supplementary Conditions have the meanings indicated below, which are applicable to both the singular and plural thereof.

The address system used in these Supplementary Conditions is the same as the address system used in the General Conditions, with the prefix "SC" added thereto.

## ARTICLE 1 - DEFINITIONS AND TERMINOLOGY

SC-1.01 Defined Terms

SC-1.01 Add to the list of definitions in Paragraph 1.01.A by inserting the following as numbered items in their proper alphabetical positions:

Construction Manager — Person or entity designated by the Owner to provide construction management services for the Project with duties, responsibilities, and limitations of the Engineer, unless stipulated otherwise. Owner has designated Carollo Engineers to provide construction management services with duties, responsibilities, and limitations therein as required by Contract.

Design Engineer — Carollo Engineers, Inc.

Final Completion - The Work is complete when it is ready for final payment as established by the Engineer's written recommendation of final payment as set forth in Paragraph 15.06.

## ARTICLE 2 - PRELIMINARY MATTERS

SC-2.01 Delivery of Bonds and Evidence of Insurance

SC-2.01 Delete Paragraphs 2.01 B. and C. in their entirety and insert the following in their place:

B. Evidence of Contractor's Insurance: When Contractor delivers the executed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner copies of the policies of insurance (including all endorsements, and identification of applicable self-insured retentions and deductibles) required to be provided by Contractor in Article 6. Contractor may block out (redact) any confidential premium or pricing information contained in any policy or endorsement furnished under this provision.

C. Evidence of Owner's Insurance: After receipt from Contractor of the executed counterparts of the Agreement and all required bonds and insurance documentation, Owner shall promptly deliver to Contractor copies of the policies of insurance to be provided by Owner under Article 6 (if any). Owner may block out (redact) any confidential premium or pricing

information contained in any policy or endorsement furnished under this provision.

## ARTICLE 5 - AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS; REFERENCE POINTS

SC-5.01 Availability of Lands

SC-5.01 Add the following requirement at the end of the last sentence of Paragraph 5.01.A:

Owner will obtain in a timely manner and pay for easements for permanent structures or permanent changes in existing facilities. If Contractor and Owner are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, as a result of any delay in Owner's furnishing the Site or a part thereof, Contractor may request an amendment to the Contract Documents as provided in Article 11.

SC-5.01 Add the following new paragraph immediately after Paragraph 5.01.C:

D. Any Work performed in public rights-of-way, in addition to conforming to the Contract Documents, shall be done in accordance with the requirements of the permit issued by the public agency in whose right-of-way the Work is located.

SC-5.03 Subsurface and Physical Conditions

SC-5.03 Add the following new paragraphs immediately after Paragraph 5.03.B:

C. The following reports of explorations and tests of subsurface conditions at or adjacent to the Site are known to Owner

1. Report dated June 20, 2022, prepared by AGEC entitled "Geotechnical Investigation East Canyon Water Reclamation Facility Proposed Expansion." The Technical Data contained in such report upon whose accuracy Contractor may rely are those indicated in the definition of Technical Data in the General Conditions.

SC-5.06 Hazardous Environmental Conditions at Site:

SC-5.06 Add the following new paragraphs immediately after Paragraph 5.06.A.3:

a. The following reports regarding Hazardous Environmental Conditions at the Site are known to Owner:

(1) None.

## ARTICLE 6 - BONDS AND INSURANCE

SC-6.03 Contractor's Insurance

SC-6.03 Add the following new paragraph immediately after Paragraph 6.03.J:

K. The limits of liability for the insurance required by Paragraph 6.03 of the General Conditions shall provide coverage for not less than the following amounts or greater where required by Laws and Regulations:

1. Workers' Compensation, and related coverages under Paragraphs 6.03.A.1 and A.2 of the General Conditions:

| | | |
|---|---|---|
| State: | | Statutory |
| Federal, if applicable (e.g., Longshoreman's): | | Statutory |
| Jones Act coverage, if applicable: | | |
| Bodily injury by accident, each accident | $ | 1,000,000 |
| Bodily injury by disease, aggregate | $ | 2,000,000 |
| Employer's Liability: | | |
| Bodily injury, each accident | $ | 1,000,000 |
| Bodily injury by disease, each employee | $ | 1,000,000 |
| Bodily injury/disease aggregate | $ | 2,000,000 |
| Foreign voluntary worker compensation | | Statutory |

2. Contractor's Commercial General Liability under Paragraphs 6.03.B and 6.03.C of the General Conditions:

| | | |
|---|---|---|
| General Aggregate | $ | 1,000,000 |
| Products - Completed Operations Aggregate | $ | 1,000,000 |
| Personal and Advertising Injury | $ | 1,000,000 |
| Each Occurrence (Bodily Injury and Property Damage) | $ | 1,000,000 |

3. Automobile Liability under Paragraph 6.03.D. of the General Conditions:

| | |
|---|---|
| Bodily Injury: | |
| Each person | 1,000,000 |
| Each accident | 1,000,000 |
| Property Damage: | |
| Each accident | 1,000,000 |
| *[or]* | |
| Combined Single Limit of | 1,000,000 |

4. Excess or Umbrella Liability:

| | |
|---|---|
| Per Occurrence | $ 20,000,000 |
| General Aggregate | $ 20,000,000 |

7. Contractor's Professional Liability:

| | |
|---|---|
| Each Claim | $ 1,000,000 |
| Annual Aggregate | $ 2,000,000 |

L. Each policy shall contain a cross liability or severability of interest clause or endorsement. Insurance covering the specified additional insureds shall be primary insurance, and all other insurance carried by the additional insureds shall be excess insurance; and with respect to workers' compensation and employer's liability, comprehensive automobile liability, commercial general liability, and umbrella liability insurance, Contractor shall require Contractor's insurance carriers to waive all rights of subrogation against Owner, Engineer, Engineer's Consultants, and their respective officers, directors, partners, employees, and agents.

SC-6.05 Property Insurance

SC-6.05 Delete Paragraph 6.05.A of the General Conditions and substitute the following in its place:

A. Contractor shall provide and maintain installation floater insurance for property under the care, custody, or control of Contractor. The installation floater insurance shall be a broad form or "all risk" policy providing coverage for all materials, supplies, machinery, fixtures, and equipment that will be incorporated into the Work. Coverage under the Contractor's installation floater will include:

1. any loss to property while in transit,
2. any loss at the Site, and

3. any loss while in storage, both on-site and off-site.

Coverage cannot be contingent on an external cause or risk, or limited to property for which the Contractor is legally liable. The Contractor will be solely responsible for any deductible carried under this coverage and claims on materials, supplies, machinery, fixture, and equipment that will be incorporated into the Work while in transit or in storage. This policy will include a waiver of subrogation applicable to Owner, Contractor, Engineer, all Subcontractors, and the officers, directors, partners, employees, agents and other consultants and subcontractors of any of them.

SC-6.05 Add the following to the list of items in Paragraph 6.05.A, as numbered items:

14. include for the benefit of Owner loss of profits and soft cost coverage including, without limitation, fixed expenses and debt service for a minimum of 12 months with a maximum deductible of 30 days, plus attorneys fees and engineering or other consultants' fees, if not otherwise covered;

17. include by express endorsement coverage of damage to Contractor's equipment.

SC-6.05 Amend the first sentence of Paragraph 6.05.B to read as follows:

All the policies of insurance (and the certificates or other evidence thereof) required to be purchased and maintained in accordance with this Paragraph 6.05 will contain a provision or endorsement that the coverage afforded will not be canceled or materially changed or renewal refused until at least 30 days prior written notice has been given to the purchasing policyholder.

## ARTICLE 7 – CONTRACTOR'S RESPONSIBILITIES

SC-7.02 Labor; Working Hours

SC-7.02 Add the following new subparagraphs immediately after Paragraph 7.02.B:

1. Regular working hours will be 7 a.m. to 6 p.m. Monday through Saturday and 9 a.m. to 6 p.m. on Sunday.

SC-7.06 Concerning Subcontractors, Suppliers, and Others

SC-7.06 Concerning Subcontractors, Suppliers, and Others: Add the following subparagraph immediately after 7.06.B:

1. Subcontracting: Contractor shall perform with Contractor's own organization work amounting to not less than 51 percent of the combined value of all items of the Work covered by the Contract.

SC-7.10 Laws and Regulations

SC-7.10 Insert the following new paragraphs immediately after Paragraph 7.10.C:

D. Contract Documents include clauses as required by Utah Code §63G 6 601 providing for adjustments in prices, time of performance, or other appropriate contract provisions.

E. Controlling law:

1. The district court shall have jurisdiction over an action, whether in law or equity, pursuant to Section 63G-6-815, Utah Procurement Code.
2. Actions under Subsection 63G-6-815 shall be initiated according to Section 63G-6-817 Statute of Limitations, Utah Procurement Code.
3. This contract is to be governed pursuant to Utah Procurement Codes and Rules.

SC-7.16 Shop Drawings, Samples, and Other Submittals

SC-7.16 Delete the Paragraph 7.16.E.2 in its entirely and insert the following in its place:

2. Contractor shall furnish required submittals with sufficient information and accuracy to obtain required approval of an item with no more than two submittals. Engineer will record Engineer's time for reviewing a third or subsequent submittal of a Shop Drawings, sample, or other item requiring approval, and Contractor shall be responsible for Engineer's charges to Owner for such time. Owner may impose a set-off against payments due to Contractor to secure reimbursement for such charges.

## ARTICLE 9 - OWNER'S RESPONSIBILITIES

SC-9.02 Replacement of Engineer

SC-9.02 Amend the first sentence of paragraph 9.02.A to read as follows:

Owner may at its discretion appoint an engineer to replace Engineer.

## ARTICLE 10 - ENGINEER'S STATUS DURING CONSTRUCTION

SC-10.03 Project Representative

SC-10.03 Add the following new paragraphs immediately after Paragraph 10.03.A:

C. The Resident Project Representative (RPR) will be Engineer's representative at the Site, will act as directed by and under the supervision of Engineer, and will confer with Engineer regarding RPR's actions.

1. General: RPR's dealings in matters pertaining to the Work in general shall be with Engineer and Contractor. RPR's dealings with Subcontractors shall only be through or with the full knowledge and approval of Contractor. RPR shall generally communicate with Owner only with the knowledge of and under the direction of Engineer.
2. Schedules: Review the progress schedule, schedule of Shop Drawing and Sample submittals, and Schedule of Values prepared by Contractor and consult with Engineer concerning acceptability.
3. Conferences and Meetings: Attend meetings with Contractor, such as preconstruction conferences, progress meetings, job conferences, and other Project-related meetings, and prepare and circulate copies of minutes thereof.

4. Liaison:
    a. Serve as Engineer's liaison with Contractor. Working principally through Contractor's authorized representative or designee, assist in providing information regarding the provisions and intent of the Contract Documents.
    b. Assist Engineer in serving as Owner's liaison with Contractor when Contractor's operations affect Owner's on-Site operations.
    c. Assist in obtaining from Owner additional details or information, when required for proper execution of the Work.
5. Interpretation of Contract Documents: Report to Engineer when clarifications and interpretations of the Contract Documents are needed and transmit to Contractor clarifications and interpretations as issued by Engineer.
6. Shop Drawings and Samples:
    a. Record date of receipt of Samples and Contractor-approved Shop Drawings.
    b. Receive Samples which are furnished at the Site by Contractor, and notify Engineer of availability of Samples for examination.
    c. Advise Engineer and Contractor of the commencement of any portion of the Work requiring a Shop Drawing or Sample submittal for which RPR believes that the submittal has not been approved by Engineer.
7. Modifications: Consider and evaluate Contractor's suggestions for modifications in Drawings or Specifications and report such suggestions, together with RPR's recommendations, if any, to Engineer. Transmit to Contractor in writing decisions as issued by Engineer.
8. Review of Work and Rejection of Defective Work:
    a. Conduct on-Site observations of Contractor's work in progress to assist Engineer in determining if the Work is in general proceeding in accordance with the Contract Documents.
    b. Report to Engineer whenever RPR believes that any part of Contractor's work in progress is defective, will not produce a completed Project that conforms generally to the Contract Documents, or will imperil the integrity of the design concept of the completed Project as a functioning whole as indicated in the Contract Documents, or has been damaged, or does not meet the requirements of any inspection, test or approval required to be made; and advise Engineer of that part of work in progress that RPR believes should be corrected or rejected or should be uncovered for observation, or requires special testing, inspection or approval.
9. Inspections, Tests, and System Start-ups:
    a. Verify that tests, equipment, and systems start-ups and operating and maintenance training are conducted in the presence of

appropriate Owner's personnel, and that Contractor maintains adequate records thereof.

b. Observe, record, and report to Engineer appropriate details relative to the test procedures and systems start-ups.

10. Records:

    a. Prepare a daily report or keep a diary or log book, recording Contractor's hours on the Site, Subcontractors present at the Site, weather conditions, data relative to questions of Change Orders, Field Orders, Work Change Directives, or changed conditions, Site visitors, deliveries of equipment or materials, daily activities, decisions, observations in general, and specific observations in more detail as in the case of observing test procedures; and send copies to Engineer.

    b. Record names, addresses, fax numbers, e-mail addresses, web site locations, and telephone numbers of all Contractors, Subcontractors, and major Suppliers of materials and equipment.

    c. Maintain records for use in preparing Project documentation.

11. Reports:

    a. Furnish to Engineer periodic reports as required of progress of the Work and of Contractor's compliance with the Progress Schedule and schedule of Shop Drawing and Sample submittals.

    b. Draft and recommend to Engineer proposed Change Orders, Work Change Directives, and Field Orders. Obtain backup material from Contractor.

    c. Immediately notify Engineer of the occurrence of any Site accidents, emergencies, acts of God endangering the Work, force majeure or delay events, damage to property by fire or other causes, or the discovery of any Constituent of Concern or Hazardous Environmental Condition.

12. Payment Requests: Review applications for payment with Contractor for compliance with the established procedure for their submission and forward with recommendations to Engineer, noting particularly the relationship of the payment requested to the Schedule of Values, Work completed, and materials and equipment delivered at the Site but not incorporated in the Work.

13. Certificates, Operation and Maintenance Manuals: During the course of the Work, verify that materials and equipment certificates, operation and maintenance manuals and other data required by the Contract Documents to be assembled and furnished by Contractor are applicable to the items actually installed and in accordance with the Contract Documents, and have these documents delivered to Engineer for review and forwarding to Owner prior to payment for that part of the Work.

14. Completion:

    a. Participate in Engineer's visits to the Site to determine Substantial Completion, assist in the determination of Substantial Completion

and the preparation of a punch list of items to be completed or corrected.

b. Participate in Engineer's final visit to the Site to determine completion of the Work, in the company of Owner and Contractor, and prepare a final punch list of items to be completed and deficiencies to be remedied.

c. Observe whether all items on the final list have been completed or corrected and make recommendations to Engineer concerning acceptance and issuance of the notice of acceptability of the work.

D. The RPR shall not:

1. Authorize any deviation from the Contract Documents or substitution of materials or equipment (including "or-equal" items).

2. Exceed limitations of Engineer's authority as set forth in the Contract Documents.

3. Undertake any of the responsibilities of Contractor, Subcontractors, or Suppliers.

4. Advise on, issue directions relative to, or assume control over any aspect of the means, methods, techniques, sequences or procedures of Contractor's work.

5. Advise on, issue directions regarding, or assume control over security or safety practices, precautions, and programs in connection with the activities or operations of Owner or Contractor.

6. Participate in specialized field or laboratory tests or inspections conducted off-site by others except as specifically authorized by Engineer.

7. Accept Shop Drawing or Sample submittals from anyone other than Contractor.

8. Authorize Owner to occupy the Project in whole or in part.

## ARTICLE 11 - AMENDING THE CONTRACT DOCUMENTS; CHANGES IN THE WORK

SC-11.01 Amending and Supplementing Contract Documents

SC-11.01 Insert the following subparagraphs immediately following 11.02.A.1.b

c. In signing a Change Order, the Owner and Contractor acknowledge and agree that:

1) the stipulated compensation (Contract Price or Contract Times, or both) set forth in the Change Order includes not only all direct costs of Contractor such as labor, material, job overhead, and profit markup, but also includes any costs for modifications or changes in sequence of work to be performed, delays, rescheduling, disruptions, extended direct overhead or general overhead, acceleration, material or other escalation which includes wages and other impact costs. This document will

become a supplement to the Contract and all Contract provisions will apply hereto. It is understood that this Change Order shall be effective on the date approved by the Owner's Representative.

2) the Change Order constitutes full mutual accord and satisfaction for the change to the Work;

3) no reservation of rights to pursue subsequent claims on the Change Order will be made by either party; and

4) no subsequent claim or amendment of the Contract Documents will arise out of or as a result of the Change Order.

SC-11.01 Insert the following paragraph immediately following 11.02.A.3

B. Changes in Contract Price are subject to prior written certification that the Change Order is within the determined project budget in accordance with Section 63G-6-602, Utah Procurement Code.

SC-11.05 Change of Contract Times

SC-11.05 Add the following new paragraphs immediately after 11.05.B:

C. Use of Float:

1. A request for adjustment of Contract Times (or Milestones), otherwise allowable under the Contract Documents, shall be granted only when the time lost or gained exceeds the float for the activity at the time of the event giving rise to the claim. Float, the amount of time between the early start date and the late start date, or the early finish date and the late finish date, is jointly owned by both Owner and Contractor whether expressly disclosed or implied in any manner.

2. Contractor shall not use float suppression techniques (including, but not limited to, preferential sequencing caused by late starts of follow-up trades, unreasonably small crews, extended durations, or imposed dates) in information provided to Engineer.

D. Weather Days:

1. The Contract Time includes a weather day allowance of 90 working days. No extension in Contract Time will be allowed for the first 90 working days lost due to weather conditions.

SC-11.06 Change Proposals

SC-11.06 Delete Paragaph 11.06.a.1 in its entirety and insert the following in its place:

1. *Procedures*: Contractor shall submit each Change Proposal to Engineer promptly (but in no event later than 15 days) after the start of the event giving rise thereto, or after such initial decision. The Contractor shall submit supporting data, including the proposed change in Contract Price or Contract Time (if any), to the Engineer and Owner within 15 days after the submittal of the Change Proposal. The supporting data shall be accompanied by a written statement that the supporting data are

accurate and complete, and that any requested time or price adjustment is the entire adjustment to which Contractor believes it is entitled as a result of said event. Engineer will advise Owner regarding the Change Proposal, and consider any comments or response from Owner regarding the Change Proposal.

## ARTICLE 13 - COST OF THE WORK; ALLOWANCES; UNIT PRICE WORK

SC-13.01 Cost of Work

SC-13.01 Delete Paragraph 13.01.B.5.c in its entirety and insert the following in its place:

c. Construction Equipment and Machinery:

1) Rentals of all construction equipment and machinery, and the parts thereof, in accordance with rental agreements approved by Owner with the advice of Engineer, and the costs of transportation, loading, unloading, assembly, dismantling, and removal thereof. All such costs shall be in accordance with the terms of said rental agreements. The rental of any such equipment, machinery, or parts shall cease when the use thereof is no longer necessary for the Work.

2) Costs for equipment and machinery owned by Contractor will be paid at a rate shown for such equipment in Blue Book rental rates. An hourly rate will be computed by dividing the monthly rates by 176. These computed rates will include all operating costs. Costs will include the time the equipment or machinery is in use on the changed Work and the costs of transportation, loading, unloading, assembly, dismantling, and removal when directly attributable to the changed Work. The cost of any such equipment or machinery, or parts thereof, shall cease to accrue when the use thereof is no longer necessary for the changed Work. Equipment or machinery with a value of less than $1,000 will be considered small tools.

SC-13.03 Unit Price Work

SC-13.03 Delete Paragraph 13.03.E in its entirety and insert the following in its place:

E. The unit price of an item of Unit Price Work shall be subject to reevaluation and adjustment under the following conditions:

1. if the extended price of a particular item of Unit Price Work amounts to 25 percent or more of the Contract Price (based on estimated quantities at the time of Contract formation) and the variation in the quantity of that particular item of Unit Price Work actually furnished or performed by Contractor differs by more than 25 percent from the estimated quantity of such item indicated in the Agreement; and

2. if there is no corresponding adjustment with respect to any other item of Work; and

3. if Contractor believes that Contractor has incurred additional expense as a result thereof, Contractor may submit a Change Proposal, or if Owner

believes that the quantity variation entitles Owner to an adjustment in the unit price, Owner may make a Claim, seeking an adjustment in the Contract Price.

## ARTICLE 15 - PAYMENTS TO CONTRACTOR; SET-OFFS; COMPLETION; CORRECTION PERIOD

SC-15.01 Progress Payments

SC-15.01 Amend the first sentence in Paragraph 15.01.B.1 to read as follows:

1. At least 30 days before the date established in the Agreement for each progress payment (but not more often than once a month), Contractor shall submit to Engineer for review an Application for Payment filled out and signed by Contractor covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents.

SC-15.01 Add following new paragraph immediately after the last sentence in 15.01.B.1.

a. Payments for stored materials and equipment shall be based only upon the actual cost of the materials and equipment to Contractor and shall not include any overhead or profit to Contractor. Partial payments will not be made for undelivered materials or equipment, except for payments associated with prepurchase vendor contracts initiated by Owner and assigned to Contractor.

SC-15.01 Amend the first sentence in Paragraph 15.01.D.1 to read as follows:

1. Thirty days after presentation of the Application for Payment to Owner with Engineer's recommendation, the amount recommended (subject to any Owner set-offs) will become due, and when due will be paid by Owner to Contractor.

SC-15.01 Add the following new paragraph immediately after Paragraph 15.01.D.1:

a. Contractor shall disburse money paid to him, including any interest Contractor receives, to Subcontractors and Suppliers within 15 days after Contractor receives the money, in direct proportion to the Subcontractors' and Suppliers' basis in the total Contract between Contractor and Owner. Any money which is payable to a Subcontractor pursuant to this Section accrues interest at the legal rate. Contractor may withhold a portion of any partial payment as may be set forth in a subcontract. Thereafter Contractor shall pay any additional funds if, in the opinion of Contractor, satisfactory progress is being made in the work under the subcontract, and the payment must be equal to that paid by Owner to Contractor for the Work performed by the Subcontractor.

    1) The Contractor may retain the amount withheld under the subcontract until the subcontract is satisfactorily completed.

    2) The amount withheld under the subcontract is due within 30 days after the acceptance of the subcontract work by Contractor.

3) Whenever Contractor receives a payment of interest earned on the amount withheld from the Contract, Contractor shall within 30 days pay to each Subcontractor that portion of the interest received from the state which is attributable to the amount of money withheld from the Subcontractor.

SC-15.03 Substantial Completion

SC-15.03 Add the following subparagraphs immediately after Paragraph 15.03.A:

1. The Work shall be Substantially Complete when the Work can treat water to required quality and transmit water in the quantity in accordance with the Contract Documents. All process and transmission equipment shall be installed and operational, or temporary arrangements satisfactory to Owner shall have been made. Operational testing must be completed prior to the date of Substantial Completion.

SC-15.03 Add the following new subparagraph to Paragraph 15.03.B:

1. If some or all of the Work has been determined not to be at a point of Substantial Completion and will require re-inspection or re-testing by Engineer, the cost of such re-inspection or re-testing, including the cost of time, travel and living expenses, shall be paid by Contractor to Owner. If Contractor does not pay, or the parties are unable to agree as to the amount owed, then Owner may impose a reasonable set-off against payments due under Article 15.

SC-15.05 Final Inspection

SC-15.05 Add the following new paragraph immediately after Paragraph 15.05.A:

B. If some or all of the Work has been determined not to be at a point of Final Completion and will require re-inspection or re-testing by Engineer, the cost of such re-inspection or re-testing, including the cost of time, travel and living expenses, shall be paid by Contractor to Owner. If Contractor does not pay, or the parties are unable to agree as to the amount owed, then Owner may impose a reasonable set-off against payments due under Article 15.

END OF DOCUMENT

## DOCUMENT 00899

## CERTIFICATE OF SUBSTANTIAL COMPLETION

**Owner:** Snyderville Basin Water Reclamation District

**Contractor:** _____

**Engineer:** Carollo Engineers, Inc.

**Project:** East Canyon Water Reclamation Facility Dewatering Equipment Installation

**Field Order Execution**

**This Certificate of Substantial Completion applies to:**

☐ All Work: ☐ The following specified portions of the Work:

_____

**Date of Substantial Completion**

The Work to which this Certificate applies has been inspected by authorized representatives of Owner, Contractor, and Engineer, and found to be substantially complete. The Date of Substantial Completion of the Work or portion thereof designated above is hereby established, subject to the provisions of the Contract pertaining to Substantial Completion. The date of Substantial Completion in the final Certificate of Substantial Completion marks the commencement of the contractual correction period and applicable warranties required by the Contract.

The Work to which this Certificate applies has been inspected by authorized representatives of Owner, Contractor, and Engineer, and found to be substantially complete. The Date of Substantial Completion of the Work or portion thereof designated above is hereby established, subject to the provisions of the Contract pertaining to Substantial Completion. The date of Substantial Completion in the final Certificate of Substantial Completion marks the commencement of the contractual correction period and applicable warranties required by the Contract.

A punch list of items to be completed or corrected is attached to this Certificate. This list may not be all-inclusive, and the failure to include any items on such list does not alter the responsibility of the Contractor to complete all Work in accordance with the Contract.

The responsibilities between Owner and Contractor for security, operation, safety, maintenance, heat, utilities, insurance, and warranties upon Owner's use or occupancy of the Work shall be as provided in the Contract, except as amended as follows:

| Field Order Execution | |
|---|---|
| Amendments to Owner's responsibilities: | ☐ None<br>☐ As follows |
| Amendments to Contractor's responsibilities: | ☐ None<br>☐ As follows: |
| The following documents are attached to and made a part of this Certificate: | |
| This Certificate does not constitute an acceptance of Work not in accordance with the Contract Documents, nor is it a release of Contractor's obligation to complete the Work in accordance with the Contract. | |

| EXECUTED BY ENGINEER: | ACCEPTED: | ACCEPTED: |
|---|---|---|
| By: _____ | By: _____ | By: _____ |
| (Authorized signature) | Owner (Authorized Signature) | Contractor (Authorized Signature) |
| Title: _____ | Title: _____ | Title: _____ |
| Date: _____ | Date: _____ | Date: _____ |

END OF DOCUMENT

# SECTION 01110

# SUMMARY OF WORK

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Detailed description of the Work.

### 1.02 THE WORK

A. The Work consists of installation of prepurchase equipment at the East Canyon Water Reclamation Facility, including 2 new rotary fan presses.

### 1.03 LOCATION OF PROJECT

A. The Work is located at 2909 West Sackett Drive, Park City, Utah 84098.

### 1.04 OWNER ASSIGNED SUBCONTRACTORS

A. None.

### 1.05 OWNER FURNISHED EQUIPMENT

A. Owner will furnish:
   1. Two rotary fan presses and associated power and control panels and instrumentation.

### 1.06 ACTIVITIES BY OTHERS

A. Activities by others which may affect performance of work include:
   1. Owner will provide all SCADA integration.

### 1.07 PARTIAL USE OR OCCUPANCY

A. Substantial Completion on the following portions of Work for Owner's occupancy including specified testing, training of Owner's personnel, and other preparations necessary for Owner's occupancy or use:
   1. Rotary Press No. 1.

B. Following occupancy, Owner will:
   1. Provide power to operate equipment and systems.
   2. Repair damage caused by Owner's occupancy.
   3. Assume responsibility to insure facilities.

C. Following occupancy, Contractor will:
   1. Limit access.
   2. Maintain cleanliness.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01140

# WORK RESTRICTIONS

## PART 1 GENERAL

### 1.01 SUMMARY

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

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

A. Plant access for Contractor will be provided at the main gate on Sackett Drive.

B. Wastewater projects:
   1. The East Canyon Wastewater Reclamation facility is the District's only means of treating domestic and industrial wastewater prior to discharging to East Canyon Creek. Impairing the operational capabilities of this treatment plant will result in serious environmental damage and monetary fines.
   2. Conduct Work in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of raw wastewater to the water quality limitations specified in the discharge permit.
   3. Conduct commissioning activities as specified in Section 01756 - Commissioning in a manner that will not impair the operational capabilities of essential elements of the treatment process or reduce the capacity of the entire treatment plant below levels sufficient to treat the quality of raw wastewater to the water quality limitations specified in the discharge permit.
   4. The status of the treatment plant shall be defined as "operational" when it is capable of treating the entire quantity of wastewater received to the water quality limits specified in the discharge permit.

### 1.03 SHUTDOWN AND CONSTRUCTION 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. Where required to minimize treatment process interruptions while complying with specified constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.

8. Final determination of the permitting of shutdowns will be the sole judgment of the Owner.
9. Owner maintains the ability to abort on the day of the scheduled shutdown.

B. General maximum plant flow work limitations:
1. Activities that disrupt plant operations are prohibited during the following flow conditions, unless otherwise approved in writing by the Owner and Engineer.
a. Flow condition: Maximum load and flow period from November 15 through April, every year.

C. Shutdown activities:
1. Scheduling:
a. Perform between the hours of 4 a.m. and 8 a.m. or as approved by Owner.
2. Unplanned shutdowns due to emergencies are not defined in this Section.

D. Process area construction constraints: The following constraints shall be observed while working in and around each of the following process areas.
1. Dewatering Building:
a. Centrifuge No. 3 shall remain in service while Rotary Press No. 1 is installed. This will require that associated equipment including Feed Pump No. 3 and both sludge conveyors remain operational during demolition of Centrifuges 1 and 2 and during installation of Rotary Press No. 1.
b. Rotary Press No. 1 and associated equipment must remain operational during installation of Rotary Press No. 2.

## 1.04 METHOD OF PROCEDURE (MOP)

A. Comply with MOP Instructions as specified in Attachment A - Method of Procedure (MOP).

B. Prepare MOP for the following conditions:
1. Shutdowns, diversions, and tie-ins to the existing facility.
2. Process start-up activities.
3. Power interruption and tie-ins.
4. Switch over between temporary and permanent facilities, equipment, piping, and electrical and instrumentation systems.
5. Process constraints requiring interruption of operating processes or utilities.
6. Include MOP for items 2 through 6 included in paragraph 1.03 E.

C. Other Work not specifically listed may require MOPs as determined necessary by the Contractor, Owner, or Engineer.

D. No consideration will be given to claims of additional time and cost associated to preparing MOPs required by the Owner and Engineer to complete this work in a manner that facilitates proper operation of the facility and compliance with effluent discharge criteria.

E. Where required to minimize treatment process interruptions while complying with specified constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.

F. Submittals:
   1. Submit Baseline Schedule, as specified in Section 01324B – Schedules and Progress Reports and with proposed MOPs.
   2. Submit MOP Log at construction progress meetings.
   3. Submit the following for each shutdown:
      a. Attachment B - Method of Procedure (MOP) Form.
      b. Attachment C - Readiness Checklist.
      c. Attachment D - Safety Checklist.
      d. Attachment E - Method of Procedure (MOP) Log.

## 1.05 COMPLIANCE WITH NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

A. The existing facility is operating under the terms of a Utah Pollutant Discharge Elimination System (UPDES) permit issued by the Utah Division of Water Quality. This permit specifies the water quality limits that the plant must meet prior to discharge of effluent. A copy of the existing permit is on file for review upon request.

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 Owner for discharge violations caused by actions of the Contractor.

## 1.06 REQUIREMENTS FOR AND MAINTAINING CONTINUOUS OPERATION OF EXISTING FACILITIES

A. Facilities or conditions required to keep the existing plant operational include, but are not limited to, the following:
   1. Electrical power including transformers, distribution wiring, and motor control centers.
   2. Headworks screening and grit removal, including truck access for disposal of dewatered screenings/grit.
   3. Influent Pump Station/temporary Influent Pump Station.
   4. RAS pumping: 1 duty pump for each clarifier in service.
   5. Chemical phosphorus removal including truck access for delivery of bulk liquid alum.
   6. Dewatering, including existing solids holding tanks and truck access for dewatered solids hauling.
   7. Access to North Maintenance Building including truck access for vactor trucks.
   8. Access to Training Building.
   9. Access to Operations Building.
   10. Laboratory facilities.
   11. Office, toilets, and washrooms.
   12. Fencing and gates.
   13. Lighting.
   14. Heating, ventilation, and air conditioning.
   15. Instrumentation, meters, controls, and telemetry equipment.
   16. Safety equipment and features.
   17. Parking for District employees and vehicles required for operation and maintenance of the East Canyon Water Reclamation Facility.

18. Telephone system.
19. Storm drainage.
20. Natural gas service.

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

C. 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.

D. General sequence of Work.

## 1.07 OPERATIONS AND MAINTENANCE ACCESS

A. Provide safe, continuous access to process control equipment for plant operations personnel.

B. Provide access on 1-hour advance notice to process control equipment for plant maintenance personnel and associated maintenance equipment.

## 1.08 UTILITIES

A. Provide advance notice to and utilize services of Blue Stake for location and marking of underground utilities operated by utility agencies other than the Owner.

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.

# 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 Owner 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 Owner 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, Owner, Engineer | 2. Pre-MOP Meeting. | More than 28 days prior to work |
| Contractor | 3. Submits MOP. | No later than 28 days prior to work |
| Owner | 4. Reviews MOP. | |
| Owner | 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 Owner 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 Owner or Engineer if the work is deemed to be minor.

STEP 3. Submits MOP.

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

STEP 4. Reviews MOP.

OPM distributes MOP Form for review by the Owner'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 Owner, 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 complete 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

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

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

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

**Submittal Title:** _____ **Spec/Dwg. Reference:** _____

| 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 Owner | | | | |
| 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 01201

# PAYMENT PROCEDURES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Procedures for submitting applications for payment and means used as a basis for Progress Payments, including:
   1. Cost Summaries.
   2. Payment for Mobilization.
   3. Commissioning and Process Start-Up.
   4. Demobilization.

### 1.02 REFERENCES

A. Occupational Safety and Health Administration (OSHA).

### 1.03 BASIS FOR PROGRESS PAYMENTS

A. Base Application for Payment on the breakdown of costs for each scheduled activity in the Progress Schedule and the Percentage of Completion for each activity. Generate Application for Payment by downloading cost data from the Progress Schedule to a spreadsheet type format. Identify each activity on the Progress Schedule that has a cost associated with it, the cost of each activity, the estimated Percent Complete for each activity, and the Value of Work Completed for both the payment period and job to date.

### 1.04 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. 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.

D. Provide Summary of Cost Information.

## 1.05 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.

## 1.06 PAYMENT FOR MOBILIZATION

A. Limit amounts included under mobilization to the following items:
   1. Moving on the site any equipment required for first month operations.
   2. Installing temporary construction power, wiring, and lighting facilities.
   3. Establishing fire protection plan and safety program.
   4. Developing construction water supply.
   5. Providing field office trailers for the Contractor and the Engineer, complete with all specified furnishings and utility services including telephones.
   6. Providing on-site sanitary facilities and potable water facilities as specified.
   7. Arranging for and erection of Contractor's work and storage yard, employee parking facilities, and entrance road.
   8. Submit all required insurance certificates and bonds.
   9. Obtaining all required permits, licenses, and fees.
   10. Submit preliminary schedule of values of the Work.
   11. Submit preliminary schedule and develop baseline schedule.
   12. Submit standardized traffic maintenance and control plans.
   13. Submit cash flow in tabular and graphical formats.
   14. Submit Contractor’s quality control plan.
   15. Submit Schedule of Submittals.
   16. Submit pre-construction photographs and videos.
   17. Provide and erect the project sign.
   18. Post all OSHA, (state agency), Department of Labor, and all other required notices.
   19. Location and flagging of construction and clearing.
   20. Have Contractor’s project manager and/or general superintendent on job site full-time.

B. Furnish data and documentation to substantiate the amounts claimed under mobilization.

C. Limit price for mobilization to no more than 5 percent of Contract Price.

D. No payment for mobilization, or any part thereof, will be recommended until all mobilization items listed above have been completed.

## 1.07 PAYMENT FOR COMMISSIONING AND PROCESS START-UP

A. Total Price for commissioning and process start-up shall not be less than 1 percent of Contract Price.

## 1.08 PAYMENT FOR DEMOBILIZATION

A. Total Price for demobilization shall not be less than 1 percent of Contract Price.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01210

# 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. Include the following amounts in Contract Price for furnishing products only:
   1. Total amount for sales taxes and Owner-requested changes: $125,000.

### 1.03 COSTS INCLUDED AND EXCLUDED IN ALLOWANCES

A. Costs included in allowances for furnishing products only:
   1. 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.

### 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 01260

# CONTRACT MODIFICATION PROCEDURES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes:
   1. Administrative and procedural requirements for executing a change in the Work.

### 1.02 PRELIMINARY REQUIREMENTS

A. Change Order Cost Basis Summary Form:
   1. Submit a sample to Engineer for review within 15 calendar days following Notice to Proceed.
      a. Items will be reviewed and their value, percentage, or calculation method mutually agreed to by the Contractor and Owner prior to executing a Change Order on the Project.
   2. Used by the Contractor for pricing each Change Order required for additions, deletions, or revisions in the Work.
   3. Include the following information:
      a. Agreed upon markups, percentages, and procedures for calculating all surcharges, etc. associated with the Cost of the Change Order Work.
      b. References for unit price information and special unit price information.
      c. Attachments with the following information:
         1) Certified labor rates breakdown.
         2) Equipment rates.
         3) Bond and insurance rates (PI&I).

### 1.03 REQUEST FOR INFORMATION OR INTERPRETATION (RFI)

A. Contractor may issue RFIs to request interpretation of the documents or to request for information that may be missing.

B. General Instructions:
   1. Number RFIs consecutively.
      a. Add a consecutive letter to the RFI number on modified submittals of the same RFI (i.e., RFI 4B).
   2. Provide RFI for 1 item.
      a. There may be exceptions when multiple items are so functionally related that expediency indicates review of the group of items as a whole.
      b. RFIs with multiple items will be rejected without review.
   3. Contractor sign and date RFIs indicating review and approval.
      a. Contractor’s signature indicates that they have satisfied RFI review responsibilities and constitutes Contractor's written approval of RFI.

b. RFIs without Contractor's signature will be returned to the Contractor unreviewed. Subsequent submittal of this information will be counted as the first resubmittal.

C. Engineer will render a written clarification, interpretation, or decision on the issue submitted or initiate an amendment or supplement to the Contract within 21 days.
   1. In the event the Contractor identifies an RFI as critical to the progress of the project, Engineer will make every effort to reduce the RFI response time.

## 1.04 PRELIMINARY PROCEDURES

A. Owner or Engineer may initiate changes by submitting a Request for Proposal (RFP) to Contractor including the following information:
   1. Detailed description of the Change, Products, and location of the change in the Project.
   2. Supplementary or revised drawings or specifications.
   3. Projected time span for making the change, and a specific statement if overtime work is authorized.
   4. A specific period of time during which the requested price will be considered valid.
   5. Such request is for information only, and is not an instruction to execute the changes, or to stop work in progress.

B. Contractor may initiate changes by submitting a Change Proposal to Engineer containing the following:
   1. Description of proposed changes.
   2. Reason for making changes.
   3. Specific period of time during which requested price will be considered valid.
   4. Effect on Total Contract Cost and/or Contract Time.
   5. Documentation supporting any change in Total Contract Cost and/or Contract Time, as appropriate.

## 1.05 WORK CHANGE DIRECTIVE AUTHORIZATION

A. In lieu of a Request for Proposal (RFP), Engineer may issue a Work Change Directive Authorization for Contractor to proceed with a change for subsequent inclusion in a Change Order.

B. Authorization will describe changes in the Work, both additions and deletions, with attachments of revised Contract Documents to define details of the change and will designate method of determining any change in the Contract Sum and/or the Contract Time, as appropriate.

C. Owner and Engineer will sign and date the Work Change Directive Authorization as authorization for the Contractor to proceed with the changes.

D. Contractor may sign and date the Work Change Directive Authorization to indicate agreement with the terms.

## 1.06 DOCUMENTATION OF CHANGE PROPOSALS

A. Change proposal:
   1. Support with sufficient substantiating data to allow Engineer to evaluate the quotation.
      a. Lump sum.
      b. Unit prices: Use previously established unit prices.
      c. Time-and-material/force account basis:
         1) Name of the Owner's authorized agent who ordered the work, and date of the order.
         2) Dates and times work was performed, and by whom.
         3) Time record, summary of hours worked, and hourly rates paid.
         4) Receipts and invoices for:
            a) Equipment used, listing dates and times of use.
            b) Products used, listing of quantities.
            c) Subcontracts.
   2. Provide additional data to support time and cost computations:
      a. Labor required.
      b. Equipment required.
      c. Products required:
         1) Recommended source of purchase and unit cost.
         2) Quantities required.
      d. Taxes, insurance, and bonds.
      e. Credit for work deleted from Contract, similarly documented.
      f. Overhead and profit.
      g. Justification for change to Contract Time.

## 1.07 PREPARATION OF CHANGE ORDERS AND FIELD ORDERS

A. Engineer will prepare each Change Order and Field Order.

B. Change Orders:
   1. Will describe changes in the Work, both additions and deletions, with attachments of revised Contract Documents to define details of the change.
   2. Will provide an accounting of the adjustment in the Contract Sum and in the Contract Time.
   3. Recommendation of Change Proposal is indicated by Engineer's signature.
   4. Upon signature and execution by Owner, the Change Proposal becomes a Change Order altering the Contract Time and Total Contract Cost, as indicated.
      a. Owner's Representative will transmit one signed copy each to Contractor and Engineer.
   5. Contractor may only request payment for changes in the Work against an approved Change Order.
   6. If either Engineer or Owner's Representative disapproves the Change Proposal, the reason for disapproval will be stated.
      a. A request for a revised proposal or cancellation of the proposal will be shown.

C. Field Orders:
   1. Order minor changes in the Work without changes in Contract Price or Contract Times.

## 1.08 LUMP-SUM/FIXED PRICE CHANGE ORDER

A. Content of Change Orders will be based on, either:
   1. Engineer's Proposal Request and Contractor's responsive Change Proposal as mutually agreed between Owner and Contractor.
   2. Contractor's Change Proposal for a change, as recommended by Engineer.

B. Owner and Engineer will sign and date the Change Order to establish the change in Contract Sum and in Contract Time and serve as authorization for the Contractor to proceed with the changes.

C. Contractor will sign and date the Change Order to indicate agreement with the terms.

## 1.09 UNIT PRICE CHANGE ORDER

A. Content of Change Orders will be based on, either:
   1. Engineer's definition of the scope of the required changes.
   2. Contractor's Change Proposal for a change, recommended by Engineer.
   3. Survey of completed work.

B. The amounts of the unit prices to be:
   1. Those stated in the Contract.
   2. Those mutually agreed upon between Owner and Contractor.

C. When quantities of each of the items affected by the Change Order can be determined prior to start of the work:
   1. Owner and Engineer will sign and date the Change Order as authorization for Contractor to proceed with the changes.
   2. Contractor will sign and date the Change Order to indicate agreement with the terms.

D. When quantities of the items cannot be determined prior to start of the work:
   1. Engineer or Owner will issue a Work Change Directive authorization directing Contractor to proceed with the change on the basis of unit prices, and will cite the applicable unit prices.
   2. At completion of the change, Engineer will determine the cost of such work based on the unit prices and quantities used.
   3. Contractor shall submit documentation to establish the number of units of each item and any claims for a change in Contract Time.

E. Owner and Engineer will sign and date the Change Order to establish the change in Contract Sum and in Contract Time and serve as authorization for the Contractor to proceed with the changes.

F. Contractor will sign and date the Change Order to indicate their agreement with the terms.

## 1.10 TIME AND MATERIAL/FORCE ACCOUNT CHANGE ORDER/WORK CHANGE DIRECTIVE AUTHORIZATION

A. Engineer will issue a Work Change Directive for the Owner's signature authorizing Contractor to proceed with the changes.

B. At completion of the change, Contractor shall submit itemized accounting and supporting data as specified in this Section.

C. Engineer will determine the allowable cost of such work, as provided in the Contract Documents.

D. Owner and Engineer will sign and date the Change Order to establish the change in Contract Sum and in Contract Time and serve as authorization for the Contractor to proceed with the changes.

E. Contractor will sign and date the Change Order to indicate their agreement.

## 1.11 CORRELATION WITH CONTRACTOR'S SUBMITTALS

A. Periodically revise Schedule of Values and Applications for Payment forms to record each Change Order as a separate item of Work, and to record the adjusted Contract Sum.

B. Periodically revise the Construction Schedule to reflect each change in Contract Time. Revise subschedules to show changes for other items of work affected by the changes.

C. Upon completion of work under a Change Order, enter pertinent changes in Record Documents.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## SECTION 01312

## PROJECT MEETINGS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: 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:
   1. Qualifications of Meeting Participants.
   2. Preconstruction Conference.
   3. Progress Meetings.
   4. Pre-Installation Meetings.
   5. Schedule Update Meetings.
   6. Quality Control Meetings.
   7. Pre-Shutdown Meetings.
   8. Pre-Process Start-up Meetings.
   9. Electrical and Instrumentation Coordination Meetings.
   10. Close-out Meeting.
   11. 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 PRECONSTRUCTION CONFERENCE

A. Upon issuance of Notice to Proceed, or earlier when mutually agreeable, Engineer will arrange preconstruction conference in place convenient for most invitees.

B. Preconstruction Conference invitees: 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 agenda.

C. Engineer will preside at conference.

D. Purpose of conference: To establish working understanding between parties and to discuss Construction Schedule, shop drawing 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.

E. Agenda may include:
   1. Adequacy of distribution of Contract Documents.
   2. Distribution and discussion of list of major subcontractors and suppliers.
   3. Proposed progress schedules and critical construction sequencing.

4. Major equipment deliveries and priorities.
5. Project coordination.
6. Designation of responsible personnel.
7. Procedures and processing of:
    a. Field decisions.
    b. Proposal requests.
    c. Submittals.
    d. Change Orders.
    e. Request for Information/Interpretations.
    f. Applications for Payment.
    g. Record Documents.
8. Use of premises:
    a. Office, construction, and storage areas.
    b. Owner's requirements.
9. Construction facilities, controls, and construction aids.
10. Temporary utilities.
11. Concrete Conference.
12. Safety and first aid procedures.
13. Security procedures.
14. Housekeeping procedures.

F. Engineer will record minutes of meeting and distribute copies of minutes within 14 days of meeting to participants and interested parties.

## 1.04 PROGRESS MEETINGS

A. Engineer will schedule and administer meetings throughout progress of the Work at maximum 2 week intervals.

B. Engineer will make arrangements for meetings, prepare agenda with copies for participants, and preside at meetings.

C. Attendance required: Owner, Engineer, Contractor, Contractor's Project Manager, superintendent, quality control manager, project scheduler, major subcontractors and suppliers as appropriate to agenda topics for each meeting.

D. Additional invitees: Owner utility companies when the Work affects their interests, and others necessary to agenda.

E. Agenda may include:
1. Review minutes of previous meeting/minutes.
2. Safety and security.
3. Construction schedule summary.
4. Review of 6 weeks schedule.
5. Review of off-site fabrication and delivery schedules.
6. Review of submittals schedule and status of submittals.
7. Request for information (RFI) status.
8. Shutdown coordination.
9. Change order management status.
10. Maintenance of quality standards (QA/QC).
11. Field observations, problems, and conflicts.

12. Commissioning and process start-up.
13. Partnering recognition status (optional).
14. General Items.
15. Action items.
16. Next meeting.

F. Engineer will record minutes and distribute copies within 14 calendar days after meeting to participants, with copies to Contractor, Owner, and those affected by decisions made.

## 1.05 PRE-INSTALLATION MEETINGS

A. When required in individual specification sections or requested by Engineer, convene pre-installation meeting at Project site before commencing work of specific section.

B. Require attendance of parties directly affecting, or affected by, Work of specific section.

C. Notify Engineer 14 calendar days in advance of meeting date.

D. Prepare agenda and preside at meeting:
1. Review conditions of installation, preparation and installation procedures.
2. Review coordination with related work.

E. Contractor will record minutes and distribute electronic copies within 7 calendar days after meeting to participants, with copies to Engineer, Owner, and those affected by decisions made.

## 1.06 PRESHUTDOWN MEETINGS

A. All short-term and longer-term shutdowns and other tie-ins that require a shutdown also require a pre-shutdown meeting at Project site prior to commencing shutdown for tie-in or modification of specific plant systems.

B. Require attendance of parties directly affecting, or affected by shutdown, including Engineer, specific work crews, Owner's construction, operations, and maintenance staff.

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

D. Prepare agenda and preside at meeting:
1. Review a shutdown plan, including conditions of shutdown, preparation, and installation procedures.
2. Review timelines and sequences.
3. Review responsibilities.
4. Review dry run plan and schedule, as necessary.
5. Review coordination with related work.

E. Contractor will record minutes and distribute copies within 5 calendar days after meeting and prior to scheduled shutdown to participants, with copies to Engineer, Owner, and those affected by decisions made.

## 1.07 PRE-PROCESS START-UP MEETINGS

A. All processes and equipment that requires testing and process start-up also requires a pre-startup meeting at Project site before commencing process start-up of specific plant systems.

B. Require attendance of parties directly affecting, or affected by process start-up and testing, including Engineer, specific work crews, Owner's construction operations, and maintenance staff.

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

D. Prepare agenda and preside at meeting:
   1. Review a Contractor prepared start-up plan, including conditions of process start-up and testing, preparation, and installation procedures.
   2. Review timelines and sequences.
   3. Review responsibilities.
   4. Review dry run plan and schedule, as necessary.
   5. Review coordination with related work.

E. Contractor will record minutes and distribute electronic copies within 5 calendar days after meeting and prior to scheduled process start-up to participants, with copies to Engineer, Owner, and those affected by decisions made.

## 1.08 ELECTRICAL AND INSTRUMENTATION COORDINATION MEETINGS

A. Electrical Meetings:
   1. Pre-submittal review meeting as specified in Section 16050 - Common Work Results for Electrical.
   2. Other meetings as required and as otherwise specified.

B. Instrumentation and Control Meetings:
   1. Pre-Submittal Conference as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   2. System Configuration Meetings (3 separate meetings) as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
   3. Other meetings as required and as otherwise specified.

## 1.09 CLOSE-OUT MEETING

A. Engineer will schedule close-out meeting.

B. Engineer will make arrangements for meeting, prepare agenda with copies for participants, and preside at meeting.

C. Attendance required: Owner, Engineer, Contractor, Contractor's Project Manager, Superintendent.

D. Agenda:
   1. Review punchlist completion.
   2. Transfer of record documents.
   3. Finalize payment.

E. Engineer will record minutes and within 5 calendar days after meeting distribute copies to participants.

## 1.10 POST CONSTRUCTION MEETING

A. Meet with and inspect the Work 11 months after date of Substantial Completion with Owner and Engineer.

B. Arrange meeting at least 7 days before meeting.

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

D. Inspect the Work and draft list of items to be completed or corrected.

E. Review service and maintenance contracts, and take appropriate corrective action when necessary.

F. Complete or correct defective work and extend correction period accordingly.

G. Require attendance of Contractor, Project Manager, or Superintendent, appropriate manufacturers and installers of major units of constructions, and affected subcontractors.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## SECTION 01320

## PROGRESS SCHEDULES AND REPORTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Preparation, submittal, and maintenance of computerized progress schedule and reports, contract time adjustments, and payment requests, including the following:
   1. Preliminary Schedule.
   2. Baseline Schedule.
   3. Monthly Schedule Updates.
   4. Weekly Summary Schedule.
   5. Schedule of Submittals.
   6. Manpower Schedule.
   7. Equipment Schedule.
   8. Commissioning and Process Start-up Schedule.
   9. As-built Schedule.

### 1.02 SCHEDULER

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

B. Qualifications of scheduler:
   1. Authority to act on behalf of Contractor.
   2. 5 years verifiable experience in preparation of complex construction schedules for projects of similar value, size, and complexity.
   3. Knowledge of critical path method (CPM) scheduling utilizing Primavera P6 Professional.

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

### 1.03 SCHEDULING FORMAT AND SOFTWARE

A. Schedule format: Utilize CPM format.

B. Prepare computerized schedule utilizing Primavera P6 Professional, most current version.
   1. Provide 1 licensed copy of the scheduling software to the Engineer, registered in the Engineer's name, for the duration of the project.
   2. The provided copy of the software shall be a standalone version for installation on a standalone computer.

## 1.04 PRECONSTRUCTION SCHEDULING MEETING

A. Engineer will conduct Preconstruction Scheduling Meeting with Contractor's Project Manager, General Superintendent, and scheduler within 7 calendar days after Notice to Proceed. This meeting is separate from the Preconstruction Conference Meeting and is intended to cover schedule issues exclusively.

B. At the meeting, review scheduling requirements. These include schedule preparation, reporting requirements, updates, revisions, and schedule delay analysis. Present schedule methodology, planned sequence of operations, and proposed activity coding structure.

C. Coding structure:
   1. Submit proposed coding structure, identifying the code fields and the associated code values it intends to use in the project schedule.
   2. A minimum, include code fields for Project Segment or Phase, Area of Work, Type of Work.
   3. Submittal/Procurement/Construction and Responsibility/Subcontractor. Refer to NETWORK DETAILS AND GRAPHICAL OUTPUT for listing of activity categories to be included in the schedule.

D. Naming convention: Name schedule files with the year, month and day of the data date, revision identifier, and a description of the schedule.
   1. Example 1: 2014_07_30 rev 1 draft baseline schedule.xer.
   2. Example 2: 2014_09_30 rev 2 sep final update.xer.

E. Filing: Post submitted files to Owner's construction document control system.

## 1.05 SCHEDULE PREPARATION

A. Preparation and submittal of Progress Schedule represents Contractor's intention to execute the Work within specified time and constraints. Failure to conform to requirement may result in termination for cause as specified in Document 00700 - General Conditions, under Suspension of Work and Termination.

B. Contractor's bid covers all costs associated with the execution of the Work in accordance with the Progress Schedule.

C. During preparation of the preliminary Progress Schedule, Engineer will facilitate Contractor's efforts by being available to answer 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. Do not exceed 15 working day duration on activities except concrete curing, submittal review, and equipment fabrication and deliveries. Where duration of continuous work exceeds 15 working days, subdivide activities by location, stationing, or other sub-element of the Work. Coordinate holidays to be observed with the Owner 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. Contract requirements are not waived by failure of Contractor to include required schedule constraints, sequences, or milestones in schedule. Contract requirements are not waived by Owner's acceptance of the schedule. In event of conflict between accepted schedule and Contract requirements, terms of Contract govern at all times, unless requirements are waived in writing by the Owner.

G. Reference schedule to working days with beginning of Contract Time as Day "1."

H. Baseline Schedule and Project Completion: Should Contractor submit a Baseline Schedule showing project completion more than 20 working days prior to Contract completion date Owner may issue Change Order, at no cost to Owner, revising time of performance of Work and Contract completion date to match Contractor's schedule completion date. Alternatively, the Owner may require the Contractor, at no cost to the Owner, to add an activity labeled "Contract Float," which shall extend the completion date to the contract completion date.

I. Contract float is for the mutual benefit of both Owner and Contractor. Changes to the project that can be accomplished within this available period of float may be made by Owner without extending the Contract time, by utilizing float. Time extensions will not be granted nor delay damages owed until Work extends beyond currently accepted Contract completion date. Likewise, Contractor may utilize float to offset delays other than delays caused by Owner. Mutual use of float can continue until all available float shown by schedule has been utilized by either Owner or Contractor, or both. At that time, extensions of the Contract time will be granted by Owner for valid Owner-caused or third party-caused delays which affect the planned completion date and which have been properly documented and demonstrated by Contractor.

J. Schedule logic: 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. Form basis for assembly of schedule logic on the following criteria:
   1. Which activities must be completed before subsequent activities can be started?
   2. Which activities can be performed concurrently?
   3. Which activities must be started immediately following completed activities?
   4. What major facility, equipment or manpower restrictions are required for sequencing these activities?

K. 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. Interim milestone dates, operational constraints: In event there are interim milestone dates and/or operational constraints set forth in Contract, show them on schedule. Do not use Zero Total Float constraint or Mandatory Finish Date on such Contract requirements.

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

N. Cost loading: All schedules:
   1. Only on-site construction activities.
   2. The sum total of all cost loaded activities equal the current value of the Contract, including change orders, at all times.
   3. Owner acceptance of the Baseline Schedule creates the Schedule of Values required as specified in Section 01292 - Schedule of Values.
   4. Provide updated Schedule of Values as the monthly Payment Application as specified in Section 01294 - Applications for Payment.
   5. Payments will not be made until updated Schedule of Values is accepted.

## 1.06 NETWORK DETAILS AND GRAPHICAL OUTPUT

A. Produce a clear, legible, and accurate calendar based, time scaled, graphical network diagram. 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. 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. Indicate the critical path for the project.

E. Delineate the specified contract duration and identify the planned completion of the Work as a milestone. Show the time period between the planned and Contract completion dates, if any, as an activity identified as project float unless a Change Order is issued to officially change the Contract completion date.

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

G. 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 Owner 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.

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

I. Identify the execution of the following:
   1. Mobilization.
   2. All required submittals and submittal review times showing 30 calendar day duration for such activities and equal amount of time for re-submittal reviews.
   3. Equipment and materials procurement/fabrication/delivery.
   4. Excavation.
   5. Shoring design and submission of detailed shoring submittals. Identify submission as a milestone.
   6. Shoring review, shoring materials procurement, shoring installation, and shoring removal.
   7. Backfill and compaction.
   8. Dewatering.
   9. Concrete, including installation of forms and reinforcement, placement of concrete, curing, stripping, finishing, and patching.
   10. Metal fastenings, framing, structures, and fabrications.
   11. Finishes including coating and painting, flooring, ceiling, and wall covering.
   12. Process equipment, including identification of ordering lead-time, factory testing, and installation.
   13. Pumps and drives, including identification of ordering lead time, factory testing, and installation.
   14. Conveying equipment including hoists and cranes, conveyor systems, and materials handling equipment, including identification of ordering lead-time and installation.
   15. Piping, fittings and appurtenances, including identification of ordering and fabrication lead time, layout, installation and testing.
   16. Valves, gates, and operators, including identification of order lead-time, installation, and testing.
   17. Plumbing specialties.
   18. Other electrical work including lighting, heating and cooling, and special systems, including identification of ordering lead-time.
   19. Preliminary testing of equipment, instrumentation, and controls.
   20. Commissioning Phase:
      a. Source Testing.
      b. Owner Training.
      c. Installation Testing.
      d. Functional Testing.
      e. Clean Water Facility Testing.
   21. Process Start-up Phase:
      a. Process Start-up.
      b. Process Operational Period.
      c. Instrumentation and Controls Performance Testing.
   22. Substantial completion.
   23. Punch list work.
   24. Demobilization.

## 1.07 SUBMITTAL OF PROGRESS SCHEDULES

A. Submit preliminary and baseline schedule.

B. Submit, on a monthly basis, updated schedules as specified.

C. Submit final schedule update as specified.

D. Submit revised schedules and time impact analyses as specified.

E. Submit schedules in the media and number of copies as follows:
   1. Three sets of the CPM network and/or bar chart (as specified by the Owner) on D-size sheets. Color-coding to be specified by the Owner.
   2. Three sets of Tabular reports listing all activities sorted numerically identifying duration, early start, late start, early finish, late finish, total float, and all predecessor/successor information.
   3. Two sets of CPM Schedule data electronic files stored on CD/DVD.

## 1.08 PRELIMINARY SCHEDULE

A. Submit Preliminary Schedule within 14 calendar days after Notice to Proceed. Include a detailed plan of operations for first 90 calendar days of Work after receipt of Notice to Proceed.

B. Meet with Engineer within 7 calendar days after receipt of Preliminary Schedule to review and make necessary adjustments. Submit revised preliminary schedule within 5 calendar days after meeting.

C. Submit schedule of costs for all activities on revised Preliminary Schedule.

D. Schedule of costs:
   1. Schedule of Values required under Section 01292 - Schedule of Values for first 30 calendar days of Work.
   2. No pay item Work shall commence until Preliminary Schedule and schedule of costs have been accepted by Owner.

E. Incorporated unchanged, the accepted Preliminary Schedule as first 90 calendar days of activity in Contractor’s Baseline Schedule.

F. Updated monthly during first 90 calendar days after Notice to Proceed.

## 1.09 BASELINE SCHEDULE

A. No more than 30 calendar days after Notice to Proceed, submit the Baseline Schedule for all Work of the project. 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.

B. Acceptance of the Baseline Schedule by the Owner is a condition precedent to making payments after the first 90 calendar days after Notice to Proceed.

## 1.10 WEATHER DAYS ALLOWANCE

A. Include as a separate identifiable activity on the critical path, an activity labeled "Weather Days Allowance." Insert this activity at the end of the schedule.

B. Weather Days are defined as a day when the Contractor is prevented by inclement weather, or conditions resulting there from, from proceeding with at least 75 percent of the normal labor and equipment force for at least 5 hours toward completion of the current critical path item, or items.

C. Duration of Weather Days Allowance is specified in Documents 00700 - General Conditions and 00800 - Supplementary Conditions.

D. Insert an activity in critical path to reflect weather day occurrences when weather days are experienced and accepted by Engineer. Identify this activity as a weather delay.

E. Reduce duration of Weather Days Allowance activity as weather delays are experienced and inserted into the schedule. Remaining weather days in Weather Day Allowance at completion of project is considered float.

F. Weather conditions that prevent or inhibit the Contractor's performance of the Work and affect the Critical Path indicated on the Schedule shall be referred to as a Weather Day. A Weather Day is defined as the Contractor being unable to perform at least 4 hours of work on the Critical Path. The Contractor shall provide a written notice to the Engineer of the occurrence of a weather day within 2 days after the onset of such weather and shall describe in reasonable detail the type of weather encountered and the Work interfered with or interrupted. A schedule update will not suffice as a written notice. The Engineer will determine if the weather day constitutes a use of a portion of the Weather Day Allowance. 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. Weather days are considered excusable delay as defined in this Section.

## 1.11 REVIEW AND ACCEPTANCE OF SCHEDULES

A. Engineer will review Baseline Schedule, Schedule Updates, Schedule Revisions, and Time Impact Analyses to ascertain compliance with specified project constraints, compliance with milestone dates, reasonableness of durations and sequence, accurate inter-relationships and completeness.

B. Engineer and Owner will issue written comments following completion of review of Baseline Schedule 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 schedule in accordance with Engineer's comments within 7 calendar days after receipt of such comments, or request joint meeting to resolve objections.

E. If Engineer requests a meeting the Contractor and all major subcontractors must participate in the meeting with Engineer.
   1. Revise and resubmit schedule within 7 calendar days after meeting.

F. Use accepted schedule for planning, organizing, and directing the work and for reporting progress.

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

## 1.12 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 in this Section under Revisions to Schedule.

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.
   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 01294 - 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 in accordance with the Revisions to Schedule.

## 1.13 REVISIONS TO SCHEDULE

A. Submit Revised Schedule within 5 calendar 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 Owner.
   1. This includes Schedule Revisions submitted for the purpose of mitigating a Contractor-caused project delay (Recovery Schedule).

## 1.14 PAYMENT REQUESTS AND CASH FLOW

A. After Baseline Schedule has been submitted and accepted by the Owner, submit on a monthly basis, a tabular and graphic report showing anticipated earnings each month of the contract period. This tabulation will be based on the summation of the cost-loaded activities each month. Submit an updated payment schedule each month showing actual earned amounts and anticipated remaining earnings.

B. Utilize cost loaded monthly Progress Schedule Updates as the applications for payment specified in Section 01294 - Applications for Payment. List payment application in Excel format of all schedule activities showing cost and percentage completion during the current month for which payment is sought. Progress payments will not be made until monthly Progress Schedule Update is provided.

## 1.15 WEEKLY SCHEDULE

A. Submit to Engineer, at every weekly progress meeting, a 6-Week Schedule showing the activities completed during the previous week and the Contractor's schedule of activities for following 5 weeks.

B. Use logic and conform to the status of the current progress schedule when producing a Weekly Schedule in CPM schedule or a bar chart format. 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.

C. The activity designations used in the Weekly Schedule must be consistent with those used in the Baseline Schedule and the monthly Schedule Updates.

D. Contractor and Engineer must agree on the format of the Weekly Schedule.

## 1.16 SCHEDULE OF VALUES

A. Requirements for Schedule of Values are specified in Section 01292 - Schedule of Values.

B. Submit, in conjunction with the Progress Schedule, a Schedule of Values identifying costs of all on-site construction activities as generated by the cost loaded schedule. Equate the aggregate of these costs to the Lump Sum Contract Price.

## 1.17 ADJUSTMENT OF CONTRACT TIMES

A. Contract Time will be adjusted only for causes specified in Contract Documents.
   1. Non-excusable delay: Non-excusable delays include actions or inactions of the Contractor, or events for which the Contractor has assumed contractual responsibility (including actions or inactions of subcontractors, suppliers, or material manufacturers at any tier) that would independently delay the completion of the Work beyond the current Contract completion date). No time extensions will be granted for non-excusable delays.
   2. Excusable delay: Events which are unforeseeable, outside the control of, and without the fault or negligence of either the Owner or the Contractor (or any party for whom either is responsible), which would independently delay the completion of the Work beyond the current Contract completion date. The Contractor is entitled to a time extension only. No other damages will be approved.
   3. Compensable delay: Actions or inactions of the Owner, or events for which the Owner has assumed contractual responsibility, which would independently delay the completion of the Work beyond the current Contract completion date. The Contractor is entitled to a time extension and delay damages.
   4. Concurrent delay: Concurrent delay is any combination of the above 3 types of delay occurring on the same calendar date.
      a. Exception to concurrent delay: Cases where the combination consists of 2 or more instances of the same type of delay occurring on the same calendar date. When one cause of delay is Owner-caused or caused by an event which is beyond the control and without the fault or negligence of

either the Owner or the Contractor and the other Contractor-caused, the Contractor is entitled only to a time extension and no delay damages.

B. If the Contractor believes that the Owner has impacted its work, such that the project completion date will be delayed, the Contractor must submit proof demonstrating the delay to the critical path. This proof, in the form of a Time Impact Analysis, may entitle the Contractor to an adjustment of contract time.

C. The 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 Owner-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, or
      c. Revising activity durations.
   2. If the project schedule's critical path and completion date are impacted as a result of adding this delay event to the 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 fragnet 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 CD containing the 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. 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. 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 jobsite or home office overhead beyond the Contractor's originally planned occupancy of the site.

I. Notify Engineer of a request for contract time adjustment. Submit request as specified in Document 00700 - General Conditions. 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. The 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 Owner, in the next monthly Schedule Update.

## 1.18 SUMMARY SCHEDULE

A. Provide Summary Schedule, which consolidates groups of activities associated with Major Items of Work shown on Baseline Schedule. Summary Schedule is intended to give an overall indication of the project schedule without a large amount of detail.

B. Submit updated Summary Schedule at weekly progress meetings and after each Schedule Update or Schedule Revision.

## 1.19 SCHEDULE OF SUBMITTALS

A. Schedule of Submittals shall include submittals required in the Contract Documents but not limited to Commissioning and Process Start-up 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 Owner.
   2. Format:
      a. Include submittals anticipated in the first 90 calendar days after Notice to Proceed using early start dates.
      b. Indicate week and month anticipated for each submittal.
      c. Indicate “Priority” submittals where review time can impact Contractor’s schedule.
         1) “Priority” indication will not alter review times specified in Section 01330 - 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 Owner making progress payments during the first 90 calendar days after Notice to Proceed.

C. Final Schedule of Submittals:
   1. Due date: After Baseline Schedule has been submitted and accepted by Owner.
   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 each submittal.
d. Indicate “Priority” submittals where review time can impact Contractor’s schedule.
1) “Priority” indication will not alter review times specified in Section 01330 - 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 Owner 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.

## 1.20 MANPOWER SCHEDULES

A. Due date: After Baseline Schedule has been submitted and accepted by Owner.

B. Format:
1. Schedule histogram depicting total craft manpower and craft manpower for Contractor’s own labor forces and those of each subcontractor.
2. Submit electronically on a computer disk 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 manpower schedule is provided.

## 1.21 EQUIPMENT SCHEDULE

A. Due date: After Baseline Schedule has been submitted and accepted by Owner.

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 on a computer disk 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.

## 1.22 COMMISSIONING AND PROCESS START-UP SCHEDULE SUBMITTAL

A. Proposed Commissioning and Process Start-up Schedule:
1. Due date: As specified in Section 01756 - Commissioning.
2. Schedule requirements: As specified in Section 01756 - Commissioning.
3. Engineer response due within 20 calendar days of receipt.
4. Contractor responsible for updating schedule and resubmitting within 10 calendar days of receipt of Engineer and Owner comments.

B. The Commissioning and Process Start-up Schedule may not be combined with the Detailed Schedule until Engineer acceptance of the Proposed Commissioning and Process Start-up Schedule.

C. Commissioning and Process Start-up Schedule 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 and Process Start-up 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.

## 1.23 FINAL SCHEDULE SUBMITTAL

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 01330

# SUBMITTAL PROCEDURES

## PART 1 GENERAL

### 1.01 SUMMARY

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

### 1.02 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 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
      a. The only exception to this requirement is when 1 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 page size will be 8 1/2 inches by 11 inches:
   2. Maximum page size will be 11 inches by 17 inches.

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

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

J. Provide submittal information from only 1 manufacturer for a specified product. Submittals with multiple manufacturers for 1 product will be rejected without review.

## 1.03 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. Specification section: 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. Drawings: 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 Owner 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 Owner 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 Owner 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 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 Owner 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.

## 1.04 SUBMITTAL IDENTIFICATION NUMBERING

A. Number each submittal using the format defined 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* | | |
| | 03300 | - | 0008 | | |
| *Example 2 Description* | *Cast-In-Place Concrete* | | *8th initial submittal* | | *First revision to the 8th initial submittal* |
| | 03300 | - | 0008 | . | 1 |

## 1.05 SUBMITTALS IN ELECTRONIC MEDIA FORMAT

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

## 1.06 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 Contractor from Contractor's responsibility for performance of requirements of Contract Documents. Neither shall Engineer's review release Contractor from fulfilling purpose of installation nor from 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 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 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 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 - Filed for record:
1) 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.

d. Receipt acknowledged with comments - Resubmit:
1) 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 1st 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 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 Engineer in writing.
4. Review costs:
   a. Costs incurred by Owner as a result of additional reviews of a particular submittal after the second time it has been reviewed shall be borne by Contractor.
   b. Reimbursement to Owner will be made by deducting such costs from Contractor's subsequent progress payments.

## 1.07 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.

## 1.08 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.

## 1.09 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) Owner: 1.
         2) Engineer: 1.
         3) Contractor: None.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## ATTACHMENT A - CONTRACTOR SUBMITTAL TRANSMITTAL FORM

## CONTRACTOR SUBMITTAL TRANSMITTAL FORM

| | | | |
|---|---|---|---|
| **Owner:** | 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 01410

# 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. Building Department: Summit County Building Department.

C. Fire Department: Park City Fire District.

### 1.03 APPLICABLE CODES

A. International Code Council (ICC).
   1. Building code:
      a. International Building Code (IBC), 2021.
      b. International Existing Building Code (IEBC), 2021.
   2. Electrical code:
      a. National Fire Protection Association (NFPA), NFPA 70: National Electrical Code (NEC), 2020.
   3. Energy code:
      a. International Energy Conservation Code (IECC), 2021.
   4. Fire code:
      a. International Fire Code (IFC), 2021.
   5. Fuel gas code:
      a. International Fuel Gas Code (IFGC), 2021.
   6. Mechanical code:
      a. International Mechanical Code (IMC), 2021.
   7. Plumbing code:
      a. International Plumbing Code (IPC), 2021.

B. Products in contact with drinking water
   1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.
      a. Certification by an independent ANSI accredited third party, including, but not limited to, NSF International, as being lead free.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

# SECTION 01450

# 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 Owner'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 OWNER'S REPRESENTATIVE OR INSPECTOR

A. Owner’s Project Representative employed or retained by Owner 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. Owner will employ and pay for specified services of an "Owner's independent testing firm" certified to perform testing and inspection as required in the technical specifications for various work and materials or stipulated in Section 01455 - Regulatory Quality Assurance to confirm Contractor's compliance with Contract Documents.

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

D. The qualifications of laboratory that will perform the testing, contracted by the Owner 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 Owner.

F. Contractor shall cooperate with Owner'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 Owner's independent testing firm 48 hours prior to expected time for operations requiring testing.
   2. Make arrangements with Owner's independent testing firm and pay for additional samples and tests required for Contractor's use.

G. Limitations of authority of testing Laboratory: Owner'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 Owner'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 Owner'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 Owner'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 nonconformance of Work or products.
   6. Perform additional tests required by Engineer.
   7. Attend preconstruction meetings and progress meetings.

K. Owner's independent testing firm individual test reports: After each test, Owner's independent testing firm will promptly submit electronically and 3 hard copies of report to Engineer and to Contractor. Include the following:
   1. Date issued.
   2. Project title and number.
   3. Name of inspector.
   4. Date and time of sampling or inspection.
   5. Identification of product and specifications section.
   6. Location in Project.
   7. Type of inspection or test.
   8. Date of test.
   9. Certified test results stamped and signed by a registered Engineer in the state where the project is located.
   10. Summary of conformance with Contract Documents.
   11. When requested by Engineer, the Owner's independent testing firm will provide interpretation of test results.

L. Owner's independent testing firm will provide monthly report of certification to identify all work performed for special inspections and other contract requirements on this project. The following certified monthly report at a minimum will include but not limited to:
   1. Results of testing.
   2. Testing logs.
   3. Outstanding deficiencies.
   4. Various statistical data.
   5. Testing curves (up to 4 types) as required by the Engineer.

## 1.10 CONTRACTOR'S RESPONSIBILITIES

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

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

C. Provide to Owner'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. Furnish electronic copies, and 5 hard copies, of product test reports.

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 Owner'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 01455

## REGULATORY QUALITY ASSURANCE

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Project regulatory requirements for quality assurance that includes Special Inspections, Special Certification, and Structural Observation.

B. The Special Certification and Special Inspections in this Section are in addition to the requirements specified in Section 01450 - Quality Control, and in the individual Sections.

### 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete.
   2. 530 - Building Code Requirements for Masonry Structures.
   3. 530.1 - Specification for Masonry Structures.

B. American Institute of Steel Construction (AISC):
   1. 360 - Specification for Structural Steel Buildings.

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

D. American Welding Society (AWS):
   1. D1.3 - Structural Welding Code - Sheet Steel.
   2. D1.4 - Structural Welding Code - Reinforcing Steel.

E. ASTM International (ASTM):
   1. A706 - Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   4. C1611 - Standard Test Method for Slump Flow of Self-Consolidating Concrete.

F. Building Code:
   1. As specified in Section 01410 - Regulatory Requirements.

G. The Masonry Society (TMS):
   1. 402 - Building Code for Masonry Structures.
   2. 602 - Specifications for Masonry Structures.

## 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. Special Certification: Certification for designated seismic systems that demonstrates compliance with performance requirements.
   2. Special Inspection: Inspection of the materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards.
   3. Special Inspection, Continuous: The full-time observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed.
   4. Special Inspection, Periodic: The part-time, or intermittent observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed and at the completion of the work.
   5. Structural Observation: The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents at significant construction stages and at completion of the structural system.

## 1.04 SUBMITTALS

A. Submit Special Certifications for designated seismic systems.

B. Schedule and coordinate the submittal of Special Inspection reports and test results prepared by others.

## 1.05 SPECIAL INSPECTION

A. Owner will employ 1 or more special inspectors who will provide Special Inspections during construction.

B. Special inspector(s) shall be qualified for inspection of the particular type of materials or operations requiring Special Inspection.

C. Testing laboratory: Testing that is required to satisfy the requirements of Special Inspection will be performed by the Owner's testing laboratory as specified in Section 01450 - Quality Control.

D. Duties of special inspector:
   1. General: Required duties of the special inspector(s) shall be as described in the Building Code.
   2. Reporting: Special inspector(s) shall provide reports of each inspection to the Owner and shall distribute copies of inspection reports to the Engineer and Contractor as required.
      a. Reports shall, at a minimum, include the following items:
         1) Date and time of inspection, and name(s) of individual(s) performing the inspection.
         2) Structures and areas of the structure where work or testing was observed.

3) Discrepancies between the requirements of the Contract Documents and the work or testing observed.
4) Other areas of deficiency in the Work.

E. Special Inspections shall not be construed as fulfilling the requirements for Structural Observation.

F. Owner or special inspector are responsible to select materials for Special Inspection.
1. Contractor shall not select materials for Special Inspection.

## 1.06 SPECIAL CERTIFICATION

A. Provide equipment that meets the special certification requirements of the Building Code.

B. Designated seismic systems shall be subject to the testing and qualification requirements of the regulatory Building Code, and shall require Special Certification as set forth in ASCE 7:
1. Mechanical equipment that is assigned an importance factor of 1.50 as specified in Section 01850 - Design Criteria.
2. All electrical equipment.

C. Special certification requirements for designated seismic systems:
1. Submittals shall include certification that the equipment is seismically qualified. Certifications are subject to review and acceptance by Owner.
2. Certifications may be at least one of the following in accordance with ASCE 7:
a. Analysis.
b. Testing.
c. Experience data.

## 1.07 STRUCTURAL OBSERVATION

A. Owner will employ 1 or more registered design professionals to provide Structural Observation(s) during construction.
1. Registered design professional will be a civil or structural engineer currently licensed as such in the state where the project is located and regularly engaged in structural design equivalent to or similar to that indicated on the Drawings.

B. Structural Observations shall not be construed as fulfilling the requirements for Special Inspections.

# PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

### 3.01 SPECIAL INSPECTIONS

A. Owner will provide Special Inspection of the following types of work as described in the Building Code wherever such work occurs, unless otherwise specified.
   1. Attachment A - Concrete - Special Inspection Schedule.
   2. Attachment B - Architectural, Mechanical, and Electrical Components - Special Inspection Schedule.
   3. Attachment D - Soils - Special Inspection Schedule.
   4. Attachment E - Structural Steel Welding - Special Inspection Schedule.
   5. Attachment F - Structural Steel Bolting - Special Inspection Schedule.
   6. Attachment G - Steel Construction - Steel Deck, Open Web Steel Joists and Joist Girders, and Cold Formed Steel Trusses - Special Inspection Schedule.

### 3.02 SPECIAL CERTIFICATION

A. Special inspector shall examine the designated seismic system(s) and determine whether the designated system components, including anchorage, are consistent with the evidence of compliance submitted for Special Certification.

### 3.03 STRUCTURAL OBSERVATION

A. The following work requires Structural Observation in accordance with the Building Code.
   1. For each structure:
      a. Completed foundation reinforcement prior to placing concrete.
      b. Masonry wall reinforcement prior to grouting the first lift.
      c. Prior to placing concrete or grout, reinforcement of walls where rebar ties are indicated on the drawings.
      d. Prior to placing concrete or grout, concrete and masonry embedments attaching floors or roofs to the wall.
      e. Metal deck welds or fasteners prior to covering them up.

### 3.04 SCHEDULE

A. Allow time necessary for Special Inspections and Structural Observation specified in this Section.

B. Sufficient notice shall be given so that the Special Inspections and Structural Observations can be performed. Allow time for individuals performing to travel to the site.

### 3.05 PROCEDURE

A. Special inspector will immediately notify the Engineer of any corrections required and follow notification with appropriate documentation.

B. Contractor shall not proceed until the work is satisfactory to the Engineer.

END OF SECTION

# ATTACHMENT A - CONCRETE - SPECIAL INSPECTION SCHEDULE

**CONCRETE - SPECIAL INSPECTION SCHEDULE**
**(Includes: Cast-in-place, precast, prestressed, precast-prestressed, and shotcrete.)**

| Verification and Inspection | Reference Standard | Frequency of Inspection[1] (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| 1. Inspect reinforcement, including prestressing tendons, and verify placement. | ACI 318<br>Building Code | | ● |
| 2. Reinforcing bar welding: | | | |
| a. Verify weldability of reinforcing bars other than ASTM A706; | AWS D1.4<br>ACI 318 | | ● |
| b. Inspect single-pass fillet welds, maximum 5/16 inch; and | AWS D1.4<br>ACI 318 | | ● |
| c. Inspect all other welds. | AWS D1.4<br>ACI 318 | ● | |
| 3. Inspect anchors cast in concrete. | ACI 318 | | ● |
| 4. Inspect anchors post-installed in hardened concrete members: | | | |
| a. Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads. | ACI 318 | ● | |
| b. Mechanical anchors and adhesive anchors not defined in 4.a. | ACI 318 | | ● |
| 5. Verify use of required design mix. | ACI 318<br>Building Code | | ● |
| 6. Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete. | ASTM C172<br>ASTM C31<br>ACI 318<br>Building Code | ● | |
| 7. Inspect concrete and shotcrete placement for proper application techniques. | ACI 318<br>Building Code | ● | |
| 8. Verify maintenance of specified curing temperature and techniques. | ACI 318<br>Building Code | | ● |
| 9. Inspect prestressed concrete for: | | | |
| a. Application of prestressing forces; and | ACI 318 | ● | |
| b. Grouting of bonded prestressing tendons. | ACI 318 | ● | |
| 10. Inspect erection of precast concrete members. | ACI 318 | | ● |
| 11. Verify in-situ concrete strength, prior to stressing of tendons in post-tensioned concrete and prior to removal of shores and forms from beams and structural slabs. | ACI 318 | | ● |

| Verification and Inspection | Reference Standard | Frequency of Inspection(1) (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| 12. Inspect formwork for shape, location and dimensions of the concrete member being formed. | ACI 318 | | ● |
| Notes:<br>(1) "●" represents a required inspection activity for the project where it occurs. | | | |

# ATTACHMENT B - ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS - SPECIAL INSPECTION SCHEDULE

**ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS - SPECIAL INSPECTION SCHEDULE**

| Verification and Inspection | Reference Standard | Frequency of Inspection[1] (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| 1. Architectural components: | | | |
| a. Cladding - exterior, weighing more than 5 psf: Erection and fastening. | Building Code | | ● |
| b. Exterior insulation and finish system (EIFS): | Building Code | | |
| c. Non-bearing walls - exterior: Erection and fastening. | Building Code | | ● |
| d. Non-bearing walls - interior, weighing more than 15 psf. | Building Code | | ● |
| e. Veneer, exterior and interior, weighing more than 5 psf: Erection and fastening. | Building Code | | ● |
| f. Access floors: Erection and anchorage. | Building Code | | ● |
| g. Suspended ceiling system: Bracing. | | | ● |
| h. Storage racks - 8 feet or greater in height: Anchorage. | Building Code | | ● |
| i. Skylight: Verification of safety compliance and labeling and installation. | Building Code | | ● |
| 2. Plumbing, mechanical, and electrical components: | | | |
| a. Anchorage of electrical equipment for emergency and standby power systems. | Building Code | | ● |
| b. Anchorage of other electrical and mechanical equipment over 400 lb. on floors or roofs. | Building Code | | ● |
| c. Installation and anchorage of pipelines carrying hazardous chemicals and their associated mechanical units. | Building Code | | ● |
| d. Installation and anchorage of pipelines greater than 8 inches in diameter. | | | ● |
| e. Installation and anchorage of ductwork designed to carry hazardous materials. | Building Code | | ● |
| f. Installation and anchorage of ductwork greater than 6 sf in cross section. | | | ● |
| g. Installation and anchorage of vibration isolation systems where Contract Documents require nominal clearance of 1/4 inch or less between the equipment support frame and its support/restraint. | Building Code | | ● |
| h. Installation of mechanical and electrical equipment, including duct work, piping | Building Code | | ● |

| Verification and Inspection | Reference Standard | Frequency of Inspection(1) (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| systems and their structural supports, where automatic fire sprinkler systems are installed. | | | |
| 3. Fire-resistance elements: | | | |
| a. Sprayed fire-resistant coatings: | Building Code | | |
| b. Mastic and intumescent coatings: | Building Code | | |
| c. Fire-resistant penetrations and joint systems: | Building Code | | |
| 4. Smoke control systems: | Building Code | | |
| Notes:<br>(1) "●" represents a required inspection activity for the project where it occurs. | | | |

# ATTACHMENT D - SOILS - SPECIAL INSPECTION SCHEDULE

## SOILS - SPECIAL INSPECTION SCHEDULE

| Verification and Inspection | Reference Standard | Frequency of Inspection[1] (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| 1. Verify materials below shallow foundations are adequate to achieve the design bearing capacity. | Building Code | | ● |
| 2. Verify excavations are extended to proper depth and have reached proper material. | Building Code | | ● |
| 3. Perform classification and testing of fill and backfill materials. | Building Code | | ● |
| 4. Verify use of proper materials, densities, and lift thicknesses during placement and compaction of fill and backfill. | Building Code | ● | |
| 5. Prior to placement of fill, observe subgrade and verify that site has been prepared properly. | Building Code | | ● |

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

## ATTACHMENT E - STRUCTURAL STEEL WELDING - SPECIAL INSPECTION SCHEDULE

## STRUCTURAL STEEL WELDING - SPECIAL INSPECTION SCHEDULE

| Verification and Inspection | Reference Standard | Frequency of Inspection[1] (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| **Inspection Tasks Prior to Welding** | AISC 360 | | |
| 1. Welding procedure specifications (WPSs) available. | | ● | |
| 2. Manufacturer certifications for welding consumables available. | | ● | |
| 3. Material identification (type/grade). | | | ● |
| 4. Welder identification system. | | | ● |
| 5. Fit-up groove welds (including joint geometry):<br>• Joint preparation.<br>• Dimensions (alignment, root opening, root face, bevel).<br>• Cleanliness (condition of steel surfaces).<br>• Tacking (tack weld quality and location).<br>• Backing type and fit (if applicable). | | | ● |
| 6. Configuration and finish of access holes. | | | ● |
| 7. Fit-up of fillet welds:<br>• Dimensions (alignment, gaps at root).<br>• Cleanliness (condition of steel surfaces).<br>• Tacking (tack weld quality and location). | | | ● |
| 8. Check welding equipment. | | | ● |
| **Inspection Tasks During Welding** | AISC 360 | | |
| 9. Use of qualified welders. | | | ● |
| 10. Control and handling of welding consumables:<br>• Packaging.<br>• Exposure control. | | | ● |
| 11. No welding over cracked tack welds. | | | ● |
| 12. Environmental conditions:<br>• Wind speed within limits.<br>• Precipitation and temperature. | | | ● |
| 13. WPS followed:<br>• Settings on welding equipment.<br>• Travel speed.<br>• Selected welding materials.<br>• Shielding gas type/flow rate.<br>• Preheat applied.<br>• Interpass temperature maintained (min/max).<br>• Proper position (F, V, H, OH). | | | ● |

| Verification and Inspection | Reference Standard | Frequency of Inspection[1] (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| 14. Welding techniques:<br>• Interpass and final cleaning.<br>• Each pass within profile limitations.<br>• Each pass meets quality requirements. | | | ● |
| **Inspection Tasks After Welding** | AISC 360 | | |
| 15. Welds cleaned. | | | ● |
| 16. Size, length, and location of welds. | | ● | |
| 17. Welds meet visual acceptance criteria:<br>• Crack prohibition.<br>• Weld/base-metal fusion.<br>• Crater cross section.<br>• Weld profiles.<br>• Weld size.<br>• Undercut.<br>• Porosity. | | ● | |
| 18. Arc strikes. | | ● | |
| 19. k-area. | | ● | |
| 20. Backing removed and weld tabs removed (if required). | | ● | |
| 21. Repair activities. | | ● | |
| 22. Document acceptance or rejection of welded joint or member. | | ● | |
| Notes:<br>(1) "●" represents a required inspection activity for the project where it occurs. | | | |

# ATTACHMENT F - STRUCTURAL STEEL BOLTING - SPECIAL INSPECTION SCHEDULE

## STRUCTURAL STEEL BOLTING - SPECIAL INSPECTION SCHEDULE

| Verification and Inspection | Reference Standard | Frequency of Inspection[1] (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| **Inspection Tasks Prior to Bolting** | AISC 360 | | |
| 1. Manufacturer's certifications available for fastener materials. | | ● | |
| 2. Fasteners marked in accordance with ASTM requirements. | | | ● |
| 3. Proper fasteners selected for the joint detail (grade, type, bolt length if threads are to be excluded from shear plane). | | | ● |
| 4. Proper bolting procedure selected for joint detail. | | | ● |
| 5. Connecting elements, including the appropriate faying surface condition and hole preparation, if specified, meet applicable requirements. | | | ● |
| 6. Pre-installation verification testing by installation personnel observed and documented for fastener assemblies and methods used. | | | ● |
| 7. Proper storage provided for bolts, nuts, washers and other fastener components. | | | ● |
| **Inspection Tasks During Bolting** | AISC 360 | | |
| 8. Fastener assemblies, of suitable condition, placed in all holes and washers (if required) are positioned as required. | | | ● |
| 9. Joint brought to the snug-tight condition prior to the pretensioning operation. | | | ● |
| 10. Fastener component not turned by the wrench prevented from rotating. | | | ● |
| 11. Fasteners are pretensioned in accordance with the RCSC Specification, progressing systematically from the most rigid point toward the free edges. | | | ● |
| **Inspection Tasks After Bolting** | AISC 360 | | |
| 12. Document acceptance or rejection of bolted connections. | | ● | |

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

# ATTACHMENT G - STEEL CONSTRUCTION - STEEL DECK; OPEN WEB STEEL JOISTS AND JOIST GIRDERS; AND COLD-FORMED STEEL TRUSSES - SPECIAL INSPECTION SCHEDULE

**STEEL CONSTRUCTION - STEEL DECK; OPEN WEB STEEL JOISTS AND JOIST GIRDERS; AND COLD-FORMED STEEL TRUSSES - SPECIAL INSPECTION SCHEDULE**

| Verification and Inspection | Reference Standard | Frequency of Inspection(1) (During Task Listed) | |
|---|---|---|---|
| | | Continuous | Periodic |
| 1. Cold-formed steel deck: | | | |
| a. Materials: Identification markings in accordance with ASTM standards specified in the approved construction documents. | Applicable ASTM material standards | | ● |
| b. Materials: Manufacturer's certified test reports. | | | ● |
| c. Welding: Floor and roof deck welds. | AWS D1.3 | | ● |
| 1. Open web steel joints and joist girders: | | | |
| a. End connections - welded or bolted | SJI specs | | ● |
| b. Bridging - horizontal or diagonal | SJI specs | | ● |

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

# SECTION 01600

# PRODUCT REQUIREMENTS

## PART 1 GENERAL

### 1.01 SUMMARY

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

### 1.02 REFERENCES

A. NSF International (NSF):
   1. 60 - Technical Requirements.
   2. 61 - Drinking Water System Components - Health Effects.

### 1.03 DEFINITIONS

A. Certificates: Documents that the work is in accordance with the Contract Documents.

B. Extra stock materials: Extra stock materials provided for the Owner's use in facility operation and maintenance.

C. Manufacturer's instructions:
   1. Stipulations, directions, and/or recommendations issued form by the manufacturer of the product addressing handling, installation, erection, and/or application of the product.

D. Products:
   1. Raw materials, finished goods, equipment, systems, and shop fabrications.

E. Product data:
   1. Public information about the product which is found in the manufacturer's catalogs or on their web site including catalog pages, data sheets, bulletins, layout drawings, exploded views, and brochures.

F. Samples:
   1. As defined in the General Conditions and Supplementary Conditions.
   2. 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.

G. Schedules:
   1. Product parts and materials lists.

H. Shop drawings:
   1. As defined in the General Conditions and Supplementary Conditions.
   2. 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 and single-line diagrams.

I. Spare parts:
   1. Duplicate parts necessary to replace a damaged or worn part of the product.
   2. Consumables such as operating fluids.

J. Special tools:
   1. 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 Owner's tool kit and that have been specifically made for use on a product for assembly, disassembly, repair, or maintenance.

K. Submittals:
   1. As defined in the General Conditions and Supplementary Conditions.
   2. Samples, product data, shop drawings, and others that demonstrate how Contractor intends to conform to the Contract Documents.

## 1.04 SUBMITTALS

A. Products in contact with drinking water:
   1. Provide certification for by an independent ANSI accredited third party.
      a. In accordance with NSF 61.
      b. Weighted average lead content of less than 0.25 percent in accordance with NSF 372.

# PART 2 PRODUCTS

## 2.01 GENERAL REQUIREMENTS

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

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

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

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

E. Provide products that bear approvals and labels as specified.

## 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. Products in contact with drinking water or water in the process of becoming drinking water in accordance with NSF 60 or NSF 61 by an independent ANSI accredited third party.

C. 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.

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

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

F. Aluminum in contact with concrete or masonry: Apply epoxy mastic as specified in Section 09960 - High-Performance Coatings, coating system EPX-M-5.

G. Provide new pipe manufactured for the project, not from manufacturer's inventory, under the following conditions:
   1. Pipes 24-inch diameter and larger.
   2. Pipe manufactured more than 6 months prior to delivery if the pipe material or its coating is subject to UV degradation.
   3. Ductile iron pipe with cement-mortar lining manufactured more than 6 months prior to delivery to the project.
   4. Steel pipe 6-inch diameter and larger.

H. Mark each length of pipe in accordance with applicable standards.

## 2.03 PRODUCT SELECTION

A. Provide products with Engineer approved submittals.

B. When products are specified by standard or specification designations of technical societies, organizations, or associations only, provide products that meet or exceed reference standard and Specifications.

C. 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.

D. 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 named manufacturers.

E. 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 one of 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.

F. 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.

G. 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 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 SHIPMENT

A. Requirements prior to shipment of equipment:
   1. Engineer approved shop drawings.
   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 01782 - Operation and Maintenance Manuals, when required by specifications.

B. Prepare products for shipment by:
   1. Tagging or marking to agree with delivery schedule or shop drawings.
   2. Including complete packing lists and bills of material with each shipment.
   3. Packaging products to facilitate handling and protection against damage during transit, handling, and storage.
   4. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

C. Transport products by methods that avoid product damage.

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

## 2.05 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 DELIVERY AND HANDLING

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

B. Provide construction equipment and personnel to handle products by methods to prevent soiling or damage.

C. 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.

D. 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) The words “Spare Parts and/or Special Tools”.
   2) Equipment tag number.
   3) Equipment manufacturer.
   4) Subassembly component, if appropriate.

## 3.02 STORAGE AND PROTECTION

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

B. 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.
   1. Storage of equipment shall be in strict accordance with the “instructions for storage” provided by the manufacturer.
      a. Including connection of heaters, lubrication, rotating shafts, etc.
   2. The Contractor shall furnish a copy of the manufacturer’s instructions for storage to the Engineer prior to storage of equipment and materials.

C. Store products with seals and legible labels intact.

D. Protect painted or coated surfaces against impact, abrasion, discoloration, and damage.
   1. Repaint or recoat damaged painted or coated surfaces.

E. 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.

F. Store moisture sensitive products in watertight enclosures.

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

H. When needed and approved by the Engineer, offsite storage location shall be within 30 miles of the project site.
   1. Provide proof of insurance coverage for products stored offsite.

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

J. Provide an equipment log and stored products log with monthly pay applications.
   1. Data includes as a minimum: The 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.

## 3.03 INSTALLATION

A. Inspect hardware or fittings prior to product installation.

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

## 3.04 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 01738

# SELECTIVE ALTERATIONS AND DEMOLITION

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Cutting or modification of existing and new work.
   2. Partial demolition of structures.
   3. In-place abandonment of pipe.

### 1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. A10.6 - Safety and Health Program Requirements for Demolition Operations.

B. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
   2. Guideline No. 310.3R - Guide for the Preparation of Concrete Surfaces for Repair Using Hydrodemolition Methods.

### 1.03 DEFINITIONS

A. Chipping hammer: A hand-operated electrical or pneumatic demolition device for removal of hardened concrete or masonry materials having a weight of less than 15 pounds and an impact frequency of greater than 2,000 blows/minute.

B. Concrete breaker: A hand-operated electrical or pneumatic demolition device for removal of hardened concrete or masonry materials having a weight greater or impact frequency less than the limits defined for a chipping hammer.

C. Coring equipment: Non-impact rotary drill with diamond cutting edges.

D. Heavy abrasive blast: Cleaning procedure by which various abrasives materials, or steel shot, are forcibly propelled by high pressure against a surface to remove loose material and produce a concrete surface roughened to ICRI Surface Profile CSP-7, or higher, as specified in ICRI 301.3R.

E. Salvage material: Materials removed from existing facilities and stored for Owner's future reuse.

### 1.04 DESCRIPTION OF WORK

A. The work includes partial demolition, cutting, and modifying of existing facilities, utilities, and/or structures.

B. These facilities may be occupied and/or operational. Satisfactory completion of the work will require that the Contractor plan activities carefully to work around unavoidable obstacles and to maintain overall stability of structures and structural elements. It will further require restoration of existing facilities, utilities, and structures that are to remain in place and that are damaged by demolition or removal operations.

## 1.05 SUBMITTALS

A. General:
   1. Submit specified in Section 01330 - Submittal Procedures.

B. Shop drawings: Include:
   1. The location of all embedded items shall be documented using diagrams and/or other media that clearly show dimensions and locations of existing structural elements, existing embedded items and any new embedded items and their relationship to each other.

C. Submittals for information only:
   1. Permits and notices authorizing demolition.
   2. Certificates of severance of utility services.
   3. Permit for transport and disposal of debris.
   4. Selective Demolition Plan.
   5. Pipe Abandonment Plan.

D. Quality assurance submittals:
   1. Qualifications of non-destructive testing agency/agencies.

E. Project record documents.

F. Drawings and/or other media documenting locations of service lines and capped utilities.

## 1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Assign relocation, removal, cutting, coring and patching to trades and workers qualified to perform the Work in manner that causes the least damage and that provides means of returning surfaces to an appearance at least equal to that of the surrounding areas unaffected by the Work.
   2. Non-destructive testing agencies: Minimum of 5 years' experience performing non-destructive testing for location of steel reinforcement in existing concrete under conditions similar to that required for this Work.

## 1.07 SEQUENCING

A. Perform Work in sequences and within times specified in Section 01140 - Work Restrictions.

B. If the facility or utility to be modified cannot be removed from service, perform the Work while the facility is in operation using procedures and equipment that do not jeopardize operation or materially reduce the efficiency of that facility.

C. Coordinate the Work with operation of the facility:
   1. Do not begin alterations of designated portions of the Work until specific permission for activities in each area has been granted by Owner in writing.
   2. Engineer will coordinate the planned procedure with facility manager.
   3. Complete Work as quickly and with as little delay as possible.

D. Operational functions of the facility that are required to be performed to facilitate the Work will be performed by facility personnel only.

E. Owner will cooperate to assist in expediting the Work.

F. When necessary for the proper operation or maintenance of portions of the facility, reschedule operations so the Work will not conflict with required operations or maintenance.

## 1.08 REGULATORY REQUIREMENTS

A. Dispose of debris in accordance with governing regulatory agencies.

B. Comply with applicable air pollution control regulations.

C. Obtain permits for building demolition, transportation of debris to disposal site and dust control.

## 1.09 PREPARATION

A. Non-destructive evaluation of existing concrete and masonry:
   1. Prior to cutting, drilling, coring, and/or any other procedure that penetrates existing concrete or masonry, retain and pay for the services of a qualified non-destructive testing agency to perform investigations to determine the location of existing steel reinforcement, plumbing, conduit, and/or other embedments in the concrete.
   2. Submit documentation of the investigations to the Engineer for review and approval as specified in Section 01330 - Submittal Procedures, before any work involving penetration of existing concrete is initiated.

B. Obtain permission from adjacent property owners when outriggers, swinging cranes, and other equipment may have to traverse or extend into adjacent property.

## 1.10 PROJECT CONDITIONS

A. Do not interfere with use of adjacent structures and elements of the facility not subject to the Work described in this Section. Maintain free and safe passage to and from such facilities.

B. Provide, erect, and maintain barricades, lighting, guardrails, and protective devices as required to protect building occupants, general public, workers, and adjoining property:
   1. Do not close or obstruct roadways without permits.
   2. Conduct operations with minimum interference to public or private roadways.

C. Prevent movement, settlement, or collapse of structures, adjacent services, sidewalks, driveways and trees:
   1. Provide and place bracing or shoring.
   2. Cease operations and notify Engineer immediately when safety of structures appears to be endangered. Take precautions to properly support structure. Do not resume operations until safety is restored.
   3. Assume liability for movement, settlement, or collapse. Promptly repair damage.

D. Arrange and pay for capping and plugging utility services. Disconnect and stub off.
   1. Notify affected utility company in advance and obtain approval before starting demolition.
   2. Place markers to indicate location of disconnected services.

E. Unknown conditions:
   1. The drawings may not represent all conditions at the site and adjoining areas. Compare actual conditions with drawings before commencement of Work.
   2. Existing utilities and drainage systems below grade are located from existing documents and from surface facilities such as manholes, valve boxes, area drains, and other surface fixtures.
   3. If existing active services encountered are not indicated or otherwise made known to the Contractor and interfere with the permanent facilities under construction, notify the Engineer in writing, requesting instructions on their disposition. Take immediate steps to ensure that the service provided is not interrupted, and do not proceed with the Work until written instructions are received from the Engineer.

## PART 2 PRODUCTS

### 2.01 SALVAGE MATERIALS

A. Materials designated for salvage to the Owner:
   1. As indicated on the Drawings.

B. Handling and storage:
   1. Prevent damage to salvaged materials during removal, handling, and transportation.
   2. Prepare salvaged materials for storage.
   3. Store salvaged materials where directed by Owner.

C. Pay costs associated with salvaging materials, including handling, transporting, and storage.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Prior to beginning selective demolition operations, perform a thorough inspection of the facility and site.
   1. Report to the Engineer defects, structural damage, and deterioration of existing construction to remain in place.

B. Examine areas affected by the Work and verify the following conditions prior to commencing demolition:
   1. Disconnection of utilities as required.
   2. Verify that utilities serving occupied or active portions of surrounding facilities will not be disturbed, except as otherwise indicated.

C. If unsatisfactory conditions exist, notify the Engineer, and do not begin demolition operations until such conditions have been corrected.

### 3.02 PREPARATION

A. Plan and organize Work to minimize inconvenience to adjacent buildings and to plant operations.

B. Selective Demolition Plan:
   1. Prepare and submit a comprehensive selective demolition plan for the Work including the following elements, at a minimum:
      a. Proposed sequence, methods, temporary support, and equipment for demolition, removal, and disposal of portions of structure(s).
      b. Provisions and procedures for salvage and delivery to Owner of salvaged items, if required.
      c. Method(s) of removing embedded relics and antiques.
      d. Detailed drawings showing proposed weatherproof closures and dustproof partitions.
   2. Plan shall be signed and sealed by a Professional Engineer registered in the state where Project is located.
   3. Submit plan a minimum 4 weeks before demolition is scheduled to begin.

C. Pipe Abandonment Plan:
   1. Prepare and submit a comprehensive Pipe Abandonment Plan for the Work.
      a. Include provisions to demonstrate and verify with camera inspection that all solids have been removed and that pipe is free of residuals.
   2. At a minimum, define the following elements:
      a. Proposed sequence, methods, cleaning procedures, or demolition, removal, and disposal of contents of the piping.
      b. Method of verification of final pipe condition.
      c. Detailed drawings showing treatment of pipe ends.
   3. Submit plan a minimum 4 weeks before abandonment is scheduled to begin.

D. Protection:
   1. Erect weatherproof closures to protect the interior of facilities and elements or equipment that are not designed for exposure to the weather.

2. Provide temporary heat, cooling, and humidity control as necessary to prevent damage to existing and new equipment and construction.
3. Maintain existing exiting paths and/or provide new paths in compliance with Building Code requirements.
4. Erect and maintain dustproof partitions as required to prevent the spread of dust, to other parts of building. Maintain negative pressure in the area where the Work is being performed to prevent the accidental spread of dust and to minimize the spread of fumes related to the Work.
5. Upon completion of Work, remove weatherproof closures and dustproof partitions.
6. Repair damaged surfaces to match adjacent surfaces.
7. Provide and maintain protective devices to prevent injury from falling objects.
8. Locate guardrails in stairwells and around open shafts to protect workers. Post clearly visible warning signs.
9. Protect the following from damage or displacement during Work.
    a. Benchmarks and survey points.
    b. Existing construction that will remain in place.
    c. Trees and landscaping designated to remain in place.
10. Carefully remove designated materials and equipment to be salvaged by Owner or reinstalled.
11. Store and protect materials and equipment to be reinstalled.

E. Layout:
1. The limits of selective demolition are indicated on the Drawings. Confine demolition operations within the limits indicated on the Drawings.
2. Lay out demolition and removal work at the site and coordinate with related Work for which demolition and removal is required.
3. Clearly mark the extent of structural elements to be removed on the actual surfaces that will be removed.
4. Arrange for Engineer's inspection of the layout extents.
5. Do not begin demolition/removal operations until the layout markings have been reviewed by the Engineer.

## 3.03 DEMOLITION

A. General:
1. Perform demolition work in accordance with ANSI A10.6.
2. Demolish designated portions of structures and appurtenances in orderly and careful manner in accordance with the Selective Demolition Plan.
3. Conduct demolition and removal work in a manner that will minimize dust and flying particles.
    a. Use water or dust palliative when necessary to prevent airborne dust.
    b. Provide and maintain hoses and connections to water main or hydrant.
4. Remove materials carefully, to the extent indicated and as required.
    a. Provide neat and orderly junctions between existing and new materials.
    b. Use methods that terminate surfaces in straight lines at natural points of division.
5. Do not remove anything beyond the limits of Work indicated without prior written authorization from the Engineer.
    a. If in doubt about whether to remove an item, obtain written authorization from the Engineer prior to proceeding.

6. Perform work so as to provide the least interference and most protection to existing facilities to remain.
7. Demolished materials:
    a. Assume possession of materials unless otherwise indicated on the Drawings or specified.
    b. Remove demolished materials from site at least weekly and dispose of them in accordance with Laws and Regulations.
    c. Do not burn or bury materials on site.

B. Demolition of concrete and masonry:
1. Demolish concrete and masonry in small sections.
    a. Perform demolition with small tools as much as possible.
    b. Blasting with explosive charges is not permitted.
2. Sawcut concrete to establish the edges of demolition, wherever possible.
    a. Do not use a concrete breaker within 6 inches of reinforcing or structural metals that are designated to remain in place.
    b. At edges that are not sawcut, remove the final 6 inches of material with a chipping hammer as defined herein. At surfaces where material is removed with a chipping hammer, follow with a heavy abrasive blast to remove all loose material and microcracking.
    c. Alternate techniques to remove concrete may be used if acceptable to the Engineer; however, techniques other than those deemed by ICRI Guideline No. 310.2R to provide a low risk of introducing microcracking will require a subsequent procedure to remove loose material and microcracked.
    d. Provide final surface preparation for repairs as specified.
3. At locations indicated on the Drawings where the existing reinforcing is to be preserved, remove concrete using methods that do not damage the reinforcing. Use one of the following techniques:
    a. Hydrodemolition techniques as outlined in ICRI Guideline No. 310.3R.
    b. Chipping hammer, as defined herein, followed by heavy abrasive blast to remove all loose material and microcracking at remaining surfaces impacted by the chipping hammer.
    c. Alternate methods may be used, only when accepted in advance by the Engineer.
    d. For all methods, provide a small, completed area for Engineer's review and acceptance. If the proposed method, in the opinion of the Engineer, damages the reinforcing, revise the removal method to remove the concrete with a less aggressive technique to protect the reinforcing.

C. Sizing of openings in existing concrete or masonry:
1. Make openings large enough to permit final alignment of pipe and fittings without deflections, but without oversizing.
2. Allow adequate space for packing around pipes and conduit to ensure watertightness.
3. If the Engineer deems the opening to be insufficient in size to accomplish these criteria, remove additional material using the procedures outlined in this Section.

D. Cutting openings in existing concrete or masonry:
1. Do not allow saw cuts to extend beyond limits of openings.

2. Create openings by the following method or other means acceptable to the Engineer that prevents over-cutting of member at corners:
    a. Core-drill through slab or wall at corners, being careful not to damage materials beyond the area to be removed.
    b. Saw cut completely through the member, between the core holes at the corners.
    c. As an alternate to sawcutting through the member, score the edges of the opening with a saw to a 1-inch depth.
        1) Provide score on both surfaces (when accessible).
        2) Remove concrete or masonry to within 6 inches of material to remain with a concrete breaker.
        3) Remove the remaining material with a chipping hammer.
    d. Remove the remaining material at the corners left by the core-drilling with a chipping hammer.
2. Prevent debris from falling into adjacent tanks or channels in service or from damaging existing equipment and other facilities.

E. In-place Abandonment of Pipe:
1. Abandoned pipe in-place as indicated on the Drawings.
2. Clean buried or exposed solids service piping to a condition free of residual.
    a. Solids service piping includes: raw wastewater (RAW WW), primary sludge or scum (PS), mixed liquor (ML), return activated sludge (RAS), waste active sludge (WAS), surface waste activated sludge (SWAS), thickened waste activated sludge (TWAS), digested sludge (DS), centrate, or other similar solids service subject to biological degradation, etc.
3. Provide closure of abandoned pipe cut ends as indicated on the Drawings using one of the following methods:
    a. Install cap.
    b. Install plug.
    c. Fill abandoned pipe as specified in Section 02312 - Controlled Low Strength Material (CLSM).

F. Buried structures:
    a. Pump out buried tanks.
    b. Remove tanks and service piping from site.
    c. Demolish tanks and foundations completely.

G. Immediately upon discovery, remove and dispose of contaminated, vermin-infested, or dangerous materials using safe means that will not endanger health of workers and public.

H. Backfill open pits and holes caused by demolition as specified in Section 02300 - Earthwork.

I. Rough grade areas affected by demolition.

J. Remove demolished materials, tools, and equipment upon completion of demolition.

## 3.04 RESTORATION

A. General:
   1. Repair damage caused by demolition to conditions equal to those that existed prior to beginning of demolition.
      a. Patch and replace portions of existing finished surfaces that are damaged, lifted, and discolored. Refinish patched portion surfaces in a manner which produces uniform color and texture to entire surface, and that matches color and texture of adjacent surfaces.
      b. When existing finish cannot be matched, refinish entire surface to nearest change of plane where angle of change exceeds 45 degrees.
   2. The cost of repairs shall be at the Contractor's expense at no increase in the Contract Price.
   3. When new construction abuts or finishes flush with existing construction, make smooth transitions. Match finish of existing construction.
   4. Where partitions are removed, patch floors, walls, and ceilings with finish materials that match existing materials.
   5. Where removal of partitions results in adjacent spaces becoming one, rework floors, walls, and ceilings to provide smooth planes without breaks, steps, or bulkheads.
      a. Where change of plane between adjacent surfaces exceeds 2 inches, request and obtain instructions for making transition from Engineer.
         1) Refinish door surfaces and edges as necessary.
   6. Trim existing doors as necessary to clear new floors.
   7. Match patched construction with adjacent construction in texture and appearance so that patch or transition is invisible at 5-foot distance.
   8. When finished surfaces are cut so that smooth transition is impossible, terminate existing surface in neat manner along straight line at natural line of division and provide appropriate trim.

B. Restore existing concrete reinforcement as follows:
   1. Where existing reinforcement is to be incorporated into the new Work, protect, clean, and extend into new concrete.
   2. Where existing reinforcement is not to be retained, cut off as follows:
      a. Where new concrete joins existing concrete at the removal line, cut reinforcement flush with concrete surface at the removal line.
      b. Where concrete surface at the removal line will become the finished surface, cut reinforcement 2 inches below the surface, paint ends with epoxy, and patch holes with dry pack mortar.

C. Restore areas affected by removal of existing equipment, equipment pads and bases, piping, supports, electrical panels, electric devices, conduits, and fasteners so little or no evidence of the previous installation remains:
   1. After removal of piping, conduit, fasteners, and other construction, fill areas in existing concrete and masonry floors, walls, and ceilings with non-shrink grout and finish smooth.
   2. Remove concrete bases for equipment and supports by:
      a. Saw cutting clean, straight lines with a depth equal to the concrete cover over reinforcement minus 1/2 inch below finished surface.
         1) Do not cut existing reinforcement in slab.
      b. Chip concrete within scored lines.

c. Cut exposed reinforcing steel and anchor bolts that will project above the repaired surface.
d. Patch with non-shrink grout to match adjacent grade and finish.

3. Terminate abandoned piping and conduits with blind flanges, caps, or plugs.
4. Where existing fasteners are not to be retained, cut off as follows:
   a. Where new concrete joins existing concrete at the removal line, cut fasteners flush with concrete surface at the removal line.
   b. Where concrete surface at the removal line will become the finished surface, cut fasteners 1 inch below the surface, paint ends with epoxy, and patch holes with epoxy grout.

## 3.05 FIELD QUALITY CONTROL

A. Do not proceed with demolition without Engineer's inspection of lay out.

B. Do not deviate from the submitted demolition plan without notifying the Engineer prior to Work.

END OF SECTION

**SECTION 01756**

**COMMISSIONING**

**TABLE OF CONTENTS**

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: 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 Owner'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>• Owner Training |
| | Installation Verification<br>• Documentation<br>• Owner Training | |
| | Functional Testing<br>• Documentation<br>• Owner Training | |

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. Owner Training: The Owner'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 Phase: The phase when Start-Up occurs.

P. Start-Up: Operating the Work with test water to verify the Work meets the Contract Documents.

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 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. Qualifications:
   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. 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 Owner Training.
         2) Provide resume stating instructor's technical expertise and instructional technology skills and experience.

B. Schedules:
   1. Commissioning Schedule containing all commissioning activities.
   2. Owner Training Schedule.

C. Certificates:
   1. Manufacturer's Certificate of Source Testing.
   2. Manufacturer's Certificate of Installation Verification.
   3. Manufacturer's Certificate of Functional Compliance.

D. Test Plans:
   1. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
      a. Engineer approval of draft Test Plans required for successful completion of Planning Phase.
   2. Submit final Test Plan a minimum of 90 calendar days prior to testing.
      a. Engineer approval of final Test Plan required prior to start of testing.

E. Test Reports:
   1. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
      a. Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
   2. Submit final Test Report a minimum of 30 calendar days after testing.

F. Manufacturer's representatives field notes and data.

G. Owner Training:
   1. Prior to the training session:
      a. Training instructor qualifications.
      b. Training course materials: Due 30 calendar days prior to initial training session.
         1) If Owner requires, Continuing Education Units (CEUs), submit training materials to state regulatory agency in sufficient time to obtain approval for training prior to the training.

2) Drafts of training agenda, lesson plan, presentation, handouts, and list of audio-visual aids.
3) Format: 1 electronic copy.

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

## 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 Owner and Engineer.

4. No substitute representatives without written approval by Owner 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 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 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. Test Plan minimum requirements:
   a. As specified in this Section and other Technical Sections.
   b. Prepared by Contractor as a result of discussions and planning emerging from regularly conducted commissioning meetings for tests as specified in the Contract.
   c. Define the following items for each Test:
      1) Purpose of the test.
      2) Identification of each item of equipment/system, 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) Product data.
         b) Appropriate calibration records.
            (1) Drawings or photographs of test stands and/or test apparatus.
         c) Duration: Determine test durations with Owner's input.
      6) Detailed step-by-step test procedures.
         a) Setup.
      7) The level of detail shall be sufficient for any witness with a rudimentary technical aptitude to be able to follow the steps and develop confidence that the tests were being performed as planned.
      8) Include all steps in the procedures.
      9) Define temporary systems (pumps, piping, etc.), shutdown requirements for existing systems.

10) Furnish labor, power, tools, equipment, instruments, and services required for and incidental to completing 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. Owner responsibilities:
   a. Schedule Owner's 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) Owner staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
      3) Maximum hours per week: 4.
      4) Days available: Monday to Thursday.
      5) Scheduling coordination:
      6) CC is responsible for the following:
         a) Coordinate schedule with the Owner'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 the Owner Training Schedule.
      3) Comply with Attachment F - Commissioning Roles and Responsibilities Matrix.

b. Procedures:
    1) Submit commissioning schedule as specified in Section 01321 - 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 Owner 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. Owner responsibilities:
        a. Furnish labor, power, chemicals, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
        b. Owner provided services, equipment, and/or materials to be as specified in Section 01110 - Summary of Work.

B. Source Testing:
    1. As specified in the Technical Sections.
    2. Source Test Plan:
        a. Engineer approval of Test Plan required prior to testing.
    3. Contractor is responsible for witness trip costs associated with Owner's and Engineer’s representatives.
        a. Include costs for at least the following:
            1) Transportation:
                a) Travel on commercial airline to and from site including related fees.
                b) Rental car to and from airport, hotel, and test site including related fees.
            2) Hotel/Meals:
                a) Hotel with an American Automobile Association 4-star rating or higher equivalent for single occupancy room per person per day.
                b) Meal allowance based on state government per diem guidelines per location.
        b. If Source Test is not ready when the witnesses arrive or if the Source Test fails, the witnesses will return home with Contractor responsible for costs associated with the trip costs described above.
            1) Contractor is responsible for rescheduling the Source Test and travel costs associated with repeated trips.
            2) Contractor is responsible for witnesses’ costs associated with retests including costs described above.
    4. Source testing is complete after successful testing, submittal of test report, and Manufacturer’s Certificate of Source Testing.
    5. Engineer approval of source testing is required.

C. Installation Verification:
   1. Overview:
      a. Verifying the installation of equipment in accordance with Manufacturer's Instructions.
   2. Prerequisite:
      a. Engineer approval of Source Testing.
   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 installation verification is required.

D. Functional Testing:
   1. Overview:
      a. Testing the function of a subsystem or system.
   2. Prerequisites:
      a. Engineer approval of Installation Verification.
      b. Engineer approval of Test Plan required prior to testing.
      c. Complete pipe, valve, and gate labeling as specified in Section 15076 - Pipe Identification prior to the start of Functional Testing.
   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:
    a. Remove, clean, and replace permanent and temporary filters and strainers in pipeline systems.
    b. Dewater and clean sumps.
    c. Dewater process units, where required by test plan.
8. Submit Manufacturer's Certificate of Functional Compliance.
9. Engineer approval of Functional Testing 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.
    o. Store the data within 24 hours of the test or document creation.
    p. Due date: Within 14 calendar days of Substantial Completion.
2. Engineer approval of documentation is required.

F. Owner Training:
1. Train Owner'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. Owner'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 Owner'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 Owner.
    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 corrective maintenance repair.
        2) If multiple classes are needed to meet the training objectives, they shall be included in the training plan.
6. Owner Training Schedule:
    a. Schedule Owner'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) Owner staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
        3) Maximum training hours per week: 16.
        4) Days available for training:
            a) Monday to Thursday.
    b. Training scheduling coordination:
        1) CC is responsible for the following:
            a) Coordinate schedule for training periods with the Owner's personnel and manufacturer's representatives (instructors).
        2) Complete Owner Training no sooner than 15 calendar days prior to Functional Testing of each system.
    c. Class logistics:
        1) Delivery time minimum: 1 hour.
        2) Delivery time maximum: 2 hours.
        3) Class agenda:
            a) Refreshment break: One 10-minute break.
        4) Schedule specific sessions:
            a) Minimum of 30 days in advance to allow Owner staffing arrangements to take place.
            b) At the times requested by the Owner, within the period 7 a.m. to 7 p.m. Monday through Friday.
                (1) Times scheduled will be at Owner's discretion.
            c) Owner approval and confirmation required for session schedules.
    d. Number of students:
        1) Estimated class size maximum: 10 staff.
        2) 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 60 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.

f. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
g. Lecturing should be less than 30 percent of class time.
h. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture to support training objectives.
i. 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 Owner’s personnel.

j. 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.

9. 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 Owner staff to ask questions and discuss the subject matter.
        5) List of documentation to be used or provided to support training.
    c. Owner 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 Owner with exclusive rights.
            a) No video recording agreements will be entered into by the Owner.
        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 Owner'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.

10. Engineer approval of Owner Training is required.

## 1.08 START-UP PHASE

A. Overview of Start-Up Phase:
1. General:
    a. Confirm proper operation of all equipment and processes.

B. Start-Up Period:
1. Contractor responsibilities:
    a. Support Owner to operate the Work.
2. Owner responsibilities:
    a. Owner to operate the Work.
    b. Owner-provided services, equipment, and/or materials to be as specified in Section 01110 - Summary of Work.
    c. Furnish labor, power, chemicals, 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 - MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

## MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

OWNER _____ 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 B - MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

## MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

OWNER _____ 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:
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 C - MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

## MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

OWNER _____ 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:
Attach test results with collected data and test report.

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 Owner's Authorized Representative: _____
(Authorized Signature)

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

## ATTACHMENT D - 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.

# SECTION 01770

# 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 Owner 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 Final 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 7-day test.

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 Owner 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 01321 - Schedules and Reports.

## 1.09 PROJECT RECORD DOCUMENTS

A. Maintain at Project site, available to Owner 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 01321 - Schedules and Reports.

## 1.10 MAINTENANCE SERVICE

A. Maintenance service as specified in technical specifications.

## 1.11 SUBSTANTIAL COMPLETION

A. Obtain Certificate of Substantial Completion.

## 1.12 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.

## 1.13 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.

## 1.14 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. Owner 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 Owner at a location on site chosen by the Owner.
   1. Provide itemized list of spare parts and special tools that matches the identification tag attached to each item.
   2. Owner 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 01782

## OPERATION AND MAINTENANCE MANUALS

### PART 1 GENERAL

### 1.01 SUMMARY

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

### 1.02 SUBMITTALS

A. Make approved manuals available at project site for use by construction personnel and Owner.

B. Draft Operation and Maintenance Manuals.

C. Final Operation and Maintenance Manuals.

### 1.03 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. Owner'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.

## 1.04 MANUAL PACKAGING

A. Label the spines:
   1. Equipment name.
   2. Tag number.
   3. Project name.
   4. Owner name.

B. Cover page:
   1. Operation and Maintenance Manual.
   2. Equipment name.
   3. Specification Section Number
   4. Equipment tag number.
   5. Owner's name.
   6. Project number and name.
   7. Date.

## 1.05 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. Online 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.

## 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 01783

## WARRANTIES AND BONDS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Warranty and bonds requirements.

### 1.02 SUBMITTALS

A. For each item of material or equipment furnished under the Contract:
   1. Submit manufacturer's warranty prior to fabrication and shipment of the item from the manufacturer's facility.
   2. Submit manufacturer's special warranty when specified.

B. Provide consolidated warranties and bonds within 15 calendar days of Substantial Completion.
   1. Contents:
      a. Organize warranty and bond documents:
         1) Include Table of Contents organized by specification section number and the name of the product or work item.
      b. Include each required warranty and bond in proper form, with full information, certified by manufacturer as required, and properly executed by Contractor, or subcontractor, supplier, or manufacturer.
      c. Provide name, address, phone number, and point of contact of manufacturer, supplier, and installer, as applicable.
   2. Hardcopy format:
      a. Submit 2 copies.
      b. Assemble in 3 D-side ring binders with durable cover.
      c. Identify each binder on the front and spine with typed or printed title "Warranties and Bonds"; Project Name or Title, and the Name Address and Telephone Number of the Contractor.
   3. Electronic copy in PDF format:
      a. Submit 1 copy.

### 1.03 OWNER'S RIGHTS

A. Owner reserves the right to reject warranties.

B. Owner reserves the right to refuse to accept Work for the project if the required warranties have not been provided.

### 1.04 RELATIONSHIP TO GENERAL WARRANTY AND CORRECTION PERIOD

A. Warranties specified for materials and equipment shall be in addition to, and run concurrent with, both Contractor's general warranty and the correction period requirements.

B. Disclaimers and limitations in specific materials and equipment warranties do not limit Contractor's general warranty, nor does such affect or limit Contractor's performance obligations under the correction period.

## 1.05 MANUFACTURER'S WARRANTY MINIMUM REQUIREMENTS

A. Written warranty issued by item's manufacturer.

B. Project-specific information, properly executed by product manufacturer, and expressly states that its provisions are for the benefit of the Owner.

C. Covers all costs associated with the correction of the defect, including but not limited to removal of defective parts, new parts, labor, and shipping.
   1. When correcting warranted Work that has failed, remove and replace other Work that had been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted Work.

D. Provides a timely response to correct the defect.
   1. Manufacturer shall provide, in a timely fashion, temporary equipment as necessary to replace warranted items requiring repair or replacement, when warranted items are in use and are critical to the treatment process, as defined by Owner.
   2. In the case that Owner has to provide temporary equipment to replace function of warranted item requiring repair or replacement, manufacturer shall reimburse Owner for such costs associated with the temporary equipment.

E. Warranty commence running on the date of substantial completion.
   1. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit warranty within 10 calendar days after acceptance, listing date of acceptance as beginning of warranty period.

F. Duration of Warranty: 1 year.

## 1.06 MANUFACTURER'S SPECIAL WARRANTY

A. Manufacturer's special warranty is a written warranty published by the manufacturer which includes the requirements specified in the section where the item is specified.
   1. Includes Project-specific information and requirements, properly executed by product manufacturer, and expressly states that its provisions are for the benefit of the Owner. Technical sections indicate Project-specific requirements that differ from the minimum warranty requirements for that item.
      a. Examples include extending the duration of manufacturer's warranty or to provide increased rights to Owner.
   2. Manufacturer's warranties commence on the date that the associated item is certified by Engineer as substantially complete.

## 1.07 WARRANTY WORK

A. Contractor's responsibilities:
   1. Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the work that incorporates the product, nor

does it relieve suppliers, manufacturers, and subcontractors required to countersign special warranties with Contractor.

B. Replacement cost:
   1. Upon determination that work covered by warranty has failed, replace or rebuild the work to an acceptable condition complying with requirement of the Contract Documents.
      a. Contractor is responsible for the cost of replacing or rebuilding defective work regardless of whether Owner has benefited from the use of the work through a portion of its anticipated useful service life.

C. Related damages and losses:
   1. When correcting warranted work that has failed, remove and replace other work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted work.

D. Owner's recourse:
   1. Written warranties are in addition to implied warranties, and shall not limit the duties, obligations, rights, and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitation on time in which Owner can enforce such other duties, obligations, rights, or remedies.

E. Reinstatement of warranty:
   1. When work covered by a warranty has failed and has been corrected by replacement or rebuilding, reinstate the warranty by written endorsement.
      a. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

## 1.08 IMPLIED WARRANTIES

A. Warranty of title and intellectual rights:
   1. Except as may be otherwise indicated in the Contract Documents, implied warranty of title required by Laws and Regulations is applicable to the Work and to materials and equipment incorporated therein.
   2. Provisions on intellectual rights, including patent fees and royalties, are in the General Conditions, as may be modified by the Supplementary Conditions.

B. Implied warranties: Duration in accordance with Laws and Regulations.

## 1.09 BONDS

A. Equipment bond and other bond requirements as specified in the technical sections.

B. Bonds commence running on the date of substantial completion.
   1. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit warranty within 10 calendar days after acceptance, listing date of acceptance as beginning of bond period.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

END OF SECTION

## SECTION 01850

## 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):

1. 7-10 - Minimum Design Loads for Buildings and Other Structures (ASCE 7).
2. 7-16 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7).

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 SUBMITTALS

A. Submit documentation of Contractor-prepared designs as specified in Technical Sections of the Contract Documents.

1. Calculations:

a. Where submittal of calculations is required:

1) Provide complete calculations, including sketches to illustrate the design concepts being evaluated, and details to fully describe proposed construction.

2. Shop drawings:

a. Shop drawings describing components and manufacturer's requirements for connections.

1) Include details for connections of components to structures and supports.

2) Include details for anchoring bracing to structures where required.

B. Delegated Design Submittals:

1. As specified in Section 01357 - Delegated Design Procedures.

# PART 2 PRODUCTS

## 2.01 DESIGN CRITERIA - SITE INFORMATION

A. Site name: East Canyon Water Reclamation Facility.

1. Location:

a. Street Address: As specified in Section 01110 - Summary of Work.

b. Elevation (approximate):

1) 6,260 feet above mean sea level.

## 2.02 DESIGN CRITERIA - REGULATORY REQUIREMENTS

A. Requirements of authorities having jurisdiction over the project are included in Section 01410 - Regulatory Requirements.

## 2.03 DESIGN CRITERIA - OPERATING ENVIRONMENT

A. Project conditions:

1. Equipment and materials for the Work shall be suitable for performance in a wastewater treatment plant**.**

2. The Drawings and Technical Sections include additional criteria and requirements relevant to specific locations, materials, and equipment.

B. Outdoor conditions:

1. Temperature criteria: -15 degrees Fahrenheit to 95 degrees Fahrenheit.

C. Indoor Conditions:

1. HVAC schedules as indicated on the Drawings.
2. Humidity:
    a. Moisture/humidity conditions: As specified, and as defined in individual equipment sections.

## 2.04 DESIGN CRITERIA - STRUCTURAL

A. General:

1. Criteria for structural design of:
    a. Equipment at locations subject to seismic events.
    b. Equipment exposed to outdoor environments.
    c. Equipment supports and bracing, and anchorage of such items to building and non-building structures.
    d. Structures provided for the Work through delegated design.
    e. Manufactured and prefabricated structures, and anchorage of such structures to foundations or other supporting elements.
2. General structural design criteria used by the engineer of record and required by the building code to be indicated on the Drawings, are included on the Contract Drawing titled "General Structural Notes." Structural design criteria specific to individual structures are included in "Design Criteria" notes on the Drawings for each structure.

B. Delegated Design:

1. Structural engineering design shall be performed by a Professional Structural Engineer licensed in the State of Utah, or by a Professional Engineer proficient in the design of the elements under consideration licensed in the State of Utah.

C. Groundwater elevation:

1. The groundwater elevation varies across the site and fluctuates seasonally. See project geotechnical reports, listed in Document 00800 - Supplementary Conditions, for information.

D. Structure risk category:

1. Determine importance factors, develop design loads, and provide detailing in accordance with the provisions of ASCE 7 and the building code specified in Section 01410 - Regulatory Requirements, based on the Structure Risk Category indicated in Table: Project Structures - Risk Category and Seismic Design Information.

E. Seismic loads:

1. Seismic design parameters: Basic parameters - ASCE 7:

a. Ground motion $MCE_R$, 5 percent damped:

1) Short periods, Ss = 0.604 g.

2) One second period, $S_1$ = 0.216 g.

b. Peak ground acceleration, $MCE_G$:

1) Peak ground acceleration, PGA = 0.264 g.

c. Mapped long-period transition period:

1) TL = 8 seconds.

2) Component response modification factor - impulsive effects, Ri: In accordance with ASCE 7, Table 15.4-2.

3) Component response modification factor - convective effects, Rc = 1.0.

d. Dry material storage structures (e.g.: silos, hoppers):

1) Include effects of stored materials.

2) Component response modification factor - impulsive effects, Ri: In accordance with ASCE 7, Table 15.4-2.

F. Wind loads:

1. Design structures and non-structural components that are exposed to wind to withstand design wind loads.

a. Reduction of wind loads based on shielding effects of surrounding structures or components is not allowed.

b. Design for wind loading is not required for non-structural components and for non-building structures located inside enclosed buildings.

2. Design parameters:

a. Basic wind speed:

1) 109 miles per hour (33 feet, 3 second gust).

b. Exposure category: C.

c. Topographic factor, Kzt: 1.0.

G. Snow loads:

1. Design for snow loading is not required for non-structural components and for non-building structures located inside enclosed buildings.

2. Design parameters:

a. Ground snow load: pg = 118 pounds per square foot.

b. Drifting:

1) Consider effects of adjacent and nearby structures and equipment on drift loads.

## PART 3 EXECUTION

### 3.01 GENERAL

A. Design in accordance with the requirements of:

1. Regulatory requirements, including but not limited to the building code specified in Section 01410 - Regulatory Requirements; AND
2. Reference standards and project-specific design criteria listed in this Section; AND
3. Specific requirements for individual elements and components of the Work as specified in subsequent Technical Sections.

B. Designs based on criteria in this Section shall not be less than what is required to comply with the codes and standards specified in Section 01410 - Regulatory Requirements.

C. In the event of conflicts between design criteria, contact Engineer for interpretation.

D. Prepare and submit designs for the following, and where Owner-delegated design is required by the Specifications.

1. Design, detailing, and anchoring of pre-engineered structures.
2. Design, detailing, and anchoring of pre-engineered structural components.
3. Anchoring of equipment and components to structures.
4. Bracing of equipment and components from structures.
5. Anchoring and bracing for distribution systems attached to or braced from structures.

E. Requirements for seismic design calculations will be waived for the following:

1. Furniture and storage racks 6 feet in height or less.
2. Moveable equipment.
3. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category A or B.
4. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category C and where the component importance factor, Ip, is equal to 1.0.

F. Requirements for wind design calculations will be waived for the following:

1. Equipment and components located inside structures, and away from the effects of wind loads.

## 3.02 DESIGN - ANCHORS FOR EQUIPMENT, COMPONENTS, AND BRACING

A. General:

1. Complete, submit, and obtain Engineer's approval of anchor designs after approval of equipment and before placement of concrete or masonry that will support or provide bracing for the equipment.
2. Adjust equipment pad sizes and add additional anchorage confinement reinforcing to provide required strength at anchorage points.
3. Supports and bracing:
    a. Design and install braces and anchors to transfer forces from equipment and components to the lateral force resisting system of the surrounding structure.
    b. Anchor and brace piping, ductwork, and electrical distribution components so that lateral or vertical displacement does not result in damage to or failure of essential architectural, mechanical, or electrical equipment.
        1) Provide supplementary framing where required to transfer forces.
        2) Detail and locate braces and anchors to minimize differential movements between components and structure.

B. Preparation:

1. Obtain manufacturer's information:
    a. Layout and location of anchors that connect to equipment base plates, sole plates, or skids.
    b. Sizes of holes for anchors that will be provided in equipment bases or support frames.

C. Analysis and design:

1. Perform and submit calculations to determine anchor designs at locations where equipment and equipment supports are connected to the supporting structure.
    a. Indicate number, size, type, and material for anchors.
2. In determining forces at locations where equipment is anchored to structures, include effects of:
    a. Equipment self-weight and operating weight.
    b. Location of equipment center of mass.
    c. Forces from equipment operation including, but not limited to:
        1) Effects of internal contents including weight, sloshing, surge, and water hammer.
        2) Equipment reactions and operating torque.
        3) Equipment vibration.

4) Thermal effects from equipment and from attached distribution systems.

5) Other load or displacement inducing conditions.

d. Forces on equipment from piping and electrical connections.

e. Forces on equipment from loads specified in this Section.

1) Include effects of wind, snow, and icing loads where applicable based on location of the equipment in the Work.

2) Design for load combinations indicated in ASCE 7, unless otherwise specified or indicated on the Drawings.

3) Seismic and wind loads: For equipment and tanks having varying weight based on the volume of contained material, determine anchor forces to accommodate the full range of filled, partially filled, and empty conditions.

3. Determine forces and overturning moments at equipment supports and at locations where supports are anchored to structures.

a. Indicate shears and associated axial forces at each anchor.

4. Do not use friction to resist sliding resulting from seismic or wind forces. Resist only by direct application of sliding loads to fasteners as bearing, shear, tension, or compression forces.

5. Using combined shears and axial forces at each anchor, design anchors and anchor groups for ductile failure.

a. Ductile failure: Anchor yield before failure of base material, typically concrete or masonry, at the anchor.

6. Anchor selection:

a. Provide anchors type indicated on the Drawings.

b. Where anchors are not specifically indicated on the Drawings, select in accordance with the following:

1) Anchors that resist seismic and wind forces:

a) Cast-in-place forged hex-head anchor bolt.

2) Anchors loaded in sustained tension:

a) Cast-in-place forged hex-head anchor bolt.

3) Anchors for reciprocating, vibrating, and rotating equipment:

a) Cast-in-place forged hex-head anchor bolt.

c. Do not use post-installed anchors, mechanical or adhesive, unless:

1) Post-installed anchors are indicated on the Drawings; or

2) Post-installed are approved by Engineer prior to placement of the surrounding concrete or masonry.

d. Anchor diameter:

1) Select diameter so that hole in base plate is not greater than 125 percent of the nominal diameter of the anchor, nor greater than the diameter of the anchor plus 1/4 inch.

7. Determine number, size, layout, and minimum effective embedment for anchors.

a. Layout includes anchor spacing and required distance(s) from anchor to edge(s) of supporting concrete or masonry.

b. Anchors in concrete: Design based on minimum specified 28-day compressive strength, f'c, as follows, unless otherwise indicated on the Drawings for the Work area:

1) Concrete placed for this Work: f'c = 3,500 pounds per square inch.

8. Prepare drawings showing construction details of anchor designs.

9. Submit design calculations and drawings prior to placement of anchors, and of the structural elements to which they will connect.

END OF SECTION

## SECTION 03055

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

### PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: 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 DEFINITIONS

A. 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 01410 - 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 01410 - 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 01850 - Design Criteria.

B. Seismic Design Category (SDC) for structures: As specified in Section 01850 - Design Criteria and as indicated on the Drawings.

# 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 or ACI 355.4 and of 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. Two-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-3G.
   3. Simpson Strong-Tie Co., Inc., SET-XP.

## 2.03 ACRYLIC AND HYBRID ADHESIVE

A. Materials:
   1. Two-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-3G.
   3. Simpson Strong-Tie Co., Inc., AT-XP.

## 2.04 ALL THREAD RODS

A. Materials: As specified in Section 05120 - Structural Steel for rods, nuts and washers.

## 2.05 REINFORCING BARS

A. As specified in Section 03200 - Concrete Reinforcing.

# 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 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 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 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 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 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 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 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 01450 - 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 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 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 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01455 - Regulatory Quality Assurance.
   2. Frequency of inspections:
      a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
      b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.
      c. Provide continuous inspection of all drilling, cleaning and bonding activities for bars and rods installed in horizontal an upwardly inclined positions.
   3. Preparation:
      a. Review Drawings and Specifications for the Work to be observed.
      b. Review adhesive manufacturer's MPII and recommended installation procedures.
      c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.

4. Inspection: Periodic:
    a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements.
        1) Concrete: Class (minimum specified compressive strength) and thickness.
        2) Environment: Temperature conditions at work area, and moisture conditions of concrete and drilled hole.
        3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "conditions of use" listed in the Evaluation Report.
        4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedure. Note initial set times observed during installation.
        5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.
    b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
        1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
        2) For ongoing installations, the special inspector visits the site at least once for every 4 hours of work during each day of installation to observe the work for compliance with material requirements and installation procedures.
5. Inspection: Continuous.
    a. Make observations as described under "Inspection - Periodic, Initial Inspection" during all drilling, cleaning, and bonding activities for all bars and rods installed.
6. Records of inspections:
    a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
    b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspection.

END OF SECTION

# SECTION 03071

# EPOXIES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Epoxy.
   2. Epoxy gel.

### 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 01330 - 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. BASF, MasterInject 1500.
      b. Dayton Superior, Unitex Pro-Poxy 100.
      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 after2-day cure) | ASTM C882 | 1,000 pounds per square inch, minimum. Concrete failure before failure of epoxy. |
| Viscosity (mixed) | | 250-550 centipoise |
| Notes: | 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. BASF, MasterEmaco ADH 327.
      b. Dayton Superior, Sure Anchor J50.
      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: | Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted. | |

## 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.

END OF SECTION

# SECTION 03102

# CONCRETE FORMWORK

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Concrete formwork.

### 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.

B. ASTM International (ASTM):
   1. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

### 1.03 DEFINITIONS

A. Green concrete: Concrete with less than 100 percent of the minimum specified compressive strength ($f'_c$).

### 1.04 SUBMITTALS

A. Information on proposed forming system:
   1. Submit in such detail as the Engineer may require to assure themselves that intent of the Specifications can be complied with by use of proposed system.
   2. Alternate combinations of plywood thickness and stud spacing may be submitted.

### 1.05 QUALITY ASSURANCE

A. Qualifications of formwork manufacturers: Use only forming systems by manufacturers having a minimum of 5 years of experience, except as otherwise specified, or accepted in writing by the Engineer.

B. Regulatory requirements: Install work of this Section in accordance with local, state, and federal regulations.

## PART 2 PRODUCTS

### 2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Design of concrete forms, falsework, and shoring in accordance with local, state, and federal regulations.
   2. Design forms and ties to withstand concrete pressures without bulging, spreading, or lifting of forms.

B. Performance requirements:
   1. Construct forms so that finished concrete conforms to shapes, lines, grades, and dimensions indicated on the Drawings.
   2. It is intended that surface of concrete after stripping presents smooth, hard, and dense finish that requires minimum amount of finishing.
   3. Provide sufficient number of forms so that the work may be performed rapidly and present uniform appearance in form patterns and finish.
   4. Use forms that are clean and free from dirt, concrete, and other debris.
      a. Coat with form release agent if required, prior to use or reuse.

### 2.02 MANUFACTURED UNITS

A. Forms: Built-up plywood:
   1. Built-up plywood forms may be substituted for prefabricated forming system subject to following minimum requirements:
      a. Size and material:
         1) Use full size 4-foot by 8-foot plywood sheets, except where smaller pieces are able to cover entire area.
         2) Sheet construction: 5-ply plywood sheets, 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
      b. Wales: Minimum 2-inch by 4-inch lumber.
      c. Studding and wales: Contain no loose knots and be free of warps, cups, and bows.

B. Forms: Steel or steel framed:
   1. Steel forms:
      a. Rigidly constructed and capable of being braced for minimum deflection of finish surface.
      b. Capable of providing finish surfaces that are flat without bows, cups, or dents.
   2. Steel framed plywood forms:
      a. Provide forms that are rigidly constructed and capable of being braced.
      b. Plywood paneling: 5-ply, 5/8-inch nominal or 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.

C. Form release agent.
   1. Effective, non-staining, bond-breaking coating compatible with form surfaces and concrete mixes used.

D. Form ties:
   1. General:
      a. Provide form ties for forming system selected that are manufactured by recognized manufacturer of concrete forming equipment.
      b. Do not use wire ties or wood spreaders of any form.
      c. Provide ties of type that accurately tie, lock, and spread forms.
      d. Provide form ties of such design that when forms are removed, they locate no metal or other material within 1-1/2 inches of the surface of the concrete.
      e. Do not allow holes in forms for ties to allow leakage during placement of concrete.
   2. Cone-snap ties:
      a. Cone-snap ties shall form a cone shaped depression in the concrete with minimum diameter of 1 inch at the surface of the concrete and minimum depth of 1-1/2 inches.
      b. Provide neoprene waterseal washer that is located near the center of the concrete.
   3. Taper ties:
      a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs are located in center third of wall thickness.

E. Incidentals:
   1. External angles:
      a. Where not otherwise indicated on the Drawings, provide with 3/4-inch bevel, formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, slabs, walls, beams, columns, and openings.
      b. Provide 1/4-inch bevel formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, walls, and slabs at expansion, and construction joints.
   2. Keyways: Steel, plastic, or lumber treated with form release agent.
   3. Dovetail anchor system: System consisting of dovetail slots cast into the concrete, dovetail anchors that tie the masonry veneer to dovetail slots, and continuous wires that are embedded in the masonry and connect to the dovetail anchors.
      a. Dovetail slot: 18 gauge, hot-dip galvanized after fabrication in accordance with ASTM A153, foam filled, and in 10-foot lengths.
         1) Manufacturers: One of the following or equal:
            a) Hohmann and Barnard, Inc., Model No. 305.
            b) Heckmann Building Products, Inc., Model No. 100.
      b. Dovetail anchors: 23 gauge, 1 inch wide, hot-dip galvanized after fabrication in accordance with ASTM A153, and with seismic notch for attachment to wire embedded in masonry.
         1) Manufacturers: One of the following or equal:
            a) Hohmann and Barnard, Inc., Model No. 303SV.
            b) Heckmann Building Products, Inc., Model No. 361.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Site verification of conditions:
   1. Do not place concrete until forms have been checked for alignment, level, and strength, and mechanical and electrical inserts or other embedded items for correct location.

### 3.02 INSTALLATION

A. Forms: Built-up plywood:
   1. Studding:
      a. Spaced at 16 inches or 24 inches on center.
      b. Closer spacing may be required depending upon strength requirements of the forms, in order to prevent any bulging surfaces on faces of finished concrete work.
      c. Install studs perpendicular to grain of exterior plies of plywood sheets.
   2. Wales: Form wales of double lumber material with minimum size as specified in this Section.
   3. Number of form reuses: Depends upon durability of surface coating or overlay used, and ability to maintain forms in condition such that they are capable of producing flat, smooth, hard, dense finish on concrete when stripped.

B. Forms: Steel or steel framed:
   1. Steel forms:
      a. Adequately brace forms for minimum deflection of finish surface.
   2. Steel framed plywood forms:
      a. Rigidly construct and brace with joints fitting closely and smoothly.
      b. Number of form reuses: Depends upon durability of surface coating or overlay used.
   3. Built-up plywood forms: As specified in this Section may be used in conjunction with steel forms or steel framed plywood forms for special forming conditions such as corbels and forming around items which will project through forms.

C. Form bracing and alignment:
   1. Line and grade: Limit deviations to tolerances which will permit proper installation of structural embedded items or mechanical and electrical equipment and piping.
   2. Formwork:
      a. Securely brace, support, tie down, or otherwise hold in place to prevent movement.
      b. Make adequate provisions for uplift pressure, lateral pressure on forms, and deflection of forms.
   3. When second lift is placed on hardened concrete: Take special precautions in form work at top of old lift and bottom of new lift to prevent:
      a. Spreading and vertical or horizontal displacement of forms.
      b. Grout "bleeding" on finish concrete surfaces.
   4. Pipe stubs, anchor bolts, and other embedded items: Set in forms where required.

5. 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.

D. Forms: Incidentals:
   1. Keyways: Construct as indicated on the Drawings.
   2. Reentrant angles: May be left square.
   3. Level strips: Install at top of wall concrete placements to maintain true line at horizontal construction joints.
   4. Inserts:
      a. Encase pipes, anchor bolts, steps, reglets, castings, and other inserts, as indicated on the Drawings or as required, in concrete.
   5. Pipe and conduit penetrations:
      a. Install pipe and conduit in structures as indicated on the Drawings, and seal with materials as specified in Section 07900 - Joint Sealants.

E. Form release agent:
   1. Apply in accordance with manufacturer's instructions.

F. Form ties:
   1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally.

## 3.03 FORM REMOVAL

A. Keep forms in place for at least the periods indicated in the following paragraphs.
   1. Vertical forms:
      a. Keep vertical forms in place for a minimum of 24 hours after concrete is placed.
      b. If, after 24 hours, concrete has sufficient strength and hardness to resist surface or other damage, forms may be removed.
   2. Other forms and shoring: Keep in place:
      a. Sides of footings: 24 hours minimum.
      b. Vertical sides of beams, girders, and similar members: 48 hours minimum.
      c. Bottom of slabs, beams, and girders: Until concrete strength reaches specified strength $f'_c$ or until shoring is installed.
      d. Shoring for slabs, beams, and girders: Shore until concrete strength reaches specified strength.
      e. Wall bracing: Brace walls until concrete strength of beams and slabs laterally supporting wall reaches specified strength.

B. Green concrete:
   1. No heavy loading on green concrete will be permitted.

## 3.04 SURFACE REPAIRS AND FINISHING

A. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified in Section 03300 - Cast-in-Place Concrete.

B. Form ties: Remove form ties from surfaces. Fill tie holes as follows:
   1. Remove form ties from surfaces.

2. Roughen cone shaped tie holes by heavy sandblasting before repair.
3. Dry pack cone shaped tie holes with dry-pack mortar as specified in Section 03600 - Grouting.
4. Taper ties:
    a. After forms and taper ties are removed from wall, plug tie holes with neoprene plug as follows:
        1) Heavy sandblast and then clean tie holes.
        2) After cleaning, drive neoprene plug into each of taper tie holes with steel rod. Final location of neoprene plug shall be in center third of wall thickness. Bond neoprene plug to concrete with epoxy.
        3) Locate steel rod in cylindrical recess and against middle of plug during driving.
            a) At no time are plugs to be driven on flat area outside cylindrical recess.
    b. Dry-pack of taper tie holes:
        1) After installing plugs in tie holes, coat tie hole surface with epoxy bonding agent and fill with dry-pack mortar as specified in Section 03600 - Grouting.
            a) Place dry-pack mortar in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
            b) Dry-pack the outside of the hole no sooner than 7 days after the inside of the hole has been dry packed.
            c) Wall surfaces in area of dry-packed tie holes: On the water side of water containing structures and the outside of below grade walls:
                (1) Cover with minimum of 10 mils of epoxy gel.
                (2) Provide epoxy gel coating on wall surfaces that extend minimum of 2 inches past dry-pack mortar filled tie holes.
                (3) Provide finish surfaces that are free from sand streaks or other voids.

## 3.05 TOLERANCES:

A. Finished concrete shall conform to shapes, lines, grades, and dimensions indicated on the Drawings.

B. Construct work within the tolerances in accordance with ACI 117, except as modified in the following paragraphs or as indicated on the Drawings.
    1. General:
        a. At certain locations in the Work, tolerances required for equipment placement and operation may be more restrictive than the general tolerance requirements of this Section.
        b. Confirm equipment manufacturers' required tolerances for location and operation of equipment that will be installed, and construct concrete to satisfy those requirements.
    2. Slabs:
        a. Slope: Uniformly sloped to drain when slope is indicated on the Drawings.
        b. Slabs indicated to be level: Have maximum vertical deviation of 1/8-inch in 10-foot horizontal length without any apparent changes in grade.

3. Circular tank walls:
   a. The Contractor may deviate from finish line indicated on the Drawings by use of forms with chord lengths not to exceed 2 feet.
4. Inserts and embedments:
   a. Set inserts and embedments to tolerances required for proper installation and operation of equipment or systems to which insert pertains.
   b. Maximum tolerances: As follows:

| Item | Tolerance |
|---|---|
| Sleeves and inserts | Plus 1/8 Minus 1/8 inches. |
| Anchor bolts: | |
| Projected ends | Plus 1/4 Minus 0.0 inches. |
| Axial alignment | Not more than 2 degrees off the axis indicated on the Drawings. |
| Setting location | Plus 1/16 Minus 1/16 inches. |

C. Remove and replace work that does not conform to required tolerances. Procedures and products employed in and resulting from such re-work shall be acceptable to the Engineer.

END OF SECTION

## SECTION 03150

## CONCRETE ACCESSORIES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Joint fillers.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   2. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

### 1.03 SUBMITTALS

A. Product data:
   1. Preformed expansion joint material: Sufficient information on each type of material for review to determine conformance of material to requirements specified.

B. Quality control submittals:
   1. Manufacturer's instructions: For materials specified in this Section that are specified to be installed with such instructions.

### 1.04 QUALITY ASSURANCE

## PART 2 PRODUCTS

### 2.01 JOINT FILLERS

A. General:
   1. Use specific type in applications as indicated on the Drawings.
   2. Do not use scrap or recycled materials to manufacture joint fillers.

B. Preformed expansion joint materials:
   1. Bituminous fiber expansion joint material:
      a. Properties:
         1) Thickness: To match joint width indicated on the Drawings.
         2) Asphalt-impregnated fiber in accordance with ASTM D1751.
      b. Manufacturers: One of the following or equal:
         1) Durajoint.

2) W.R. Meadows, SealTight Fibre Expansion Joint.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Joints:
   1. Construct construction and expansion joints as indicated on the Drawings.
   2. Preformed expansion joint material: Fasten expansion joint strips to concrete, masonry, or forms with adhesive. No nailing will be permitted, nor shall expansion joint strips be placed without fastening.

END OF SECTION

## SECTION 03200

## CONCRETE REINFORCING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Reinforcing bars.
      a. Carbon steel.
   2. Thread bars.
   3. Bar supports.
   4. Tie wires.
   5. Welded wire fabric.
   6. Mechanical reinforcing bar couplers.

### 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.
   2. SP-66 - ACI Detailing Manual.

B. American Iron and Steel Institute (AISI).

C. American Welding Society (AWS):
   1. D1.4 - Structural Welding Code - Reinforcing Steel.

D. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
   2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
   4. A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   5. A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   6. A1064 - Standard Specification of Carbon-Steel wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

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

F. ICC Evaluation Service (ICC-ES):
   1. AC133 - Acceptance Criteria for Mechanical Connector Systems for Steel Reinforcing Bars.
   2. AC347 - Acceptance Criteria for Headed Deformed Bars.

## 1.03 DEFINITIONS

A. Architectural concrete: Concrete surfaces that will be exposed to view in the finished work.
   1. Additionally, for purposes of this Section,includes:
      a. Concrete surfaces that are designated to receive paints or coatings.
      b. Exposed concrete in open basins, channels, and similar liquid containing structures:Surfaces shall be considered exposed to view if located above a line 2 feet below the normal operating water surface elevation in that structure.

B. Bars: Reinforcement or reinforcing bars as specified in this Section.

C. Evaluation Report: Report prepared by ICC-ES , or by other testing agency acceptable to the 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 its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.

D. Give away bars: Reinforcing bars that are not required by the Contract Documents, but are installed by the Contractor to provide support for the required reinforcing bars.

E. Wire supports: Metal reinforcing supports constructed of steel wire as specified. Includes individual high chairs, continuous high chairs, bolsters and other similar configurations and shapes.

## 1.04 SUBMITTALS

A. General:
   1. Submit in accordance with Section 01330 - Submittal Procedures.
   2. Changes to reinforcement in Contract Documents:
      a. Indicate in a separate letter submitted with shop drawings any changes to reinforcement indicated on the Drawings or specified.
      b. Such changes will not be acceptable unless Engineer has accepted them in writing.

B. Product data:
   1. Bar supports:
      a. Wire bar supports:
         1) Schedule of support materials to be provided and locations of use.
      b. Precast concrete bar supports ("dobies"):
         1) Manufacturer's data indicating compression strength of concrete and confirming dimensions and thickness(es).height(s) to be provided for each location where used.
   2. Mechanical reinforcing bar couplers. For each type and/or series to be provided:
      a. Evaluation Report documenting compliance with the requirements of ICC-ES AC133.

b. Details, properties, and dimensions of couplers. Include type or size identification, and bar size(s) and grade(s) for which the coupler is suitable.
c. Manufacturer’s installation and testing instructions.
d. Manufacturer's statement that products installed in accordance with manufacturer's recommended procedures will develop strengths and limit slip as specified in this Section.

3. Mechanical reinforcing bar end anchors (terminators).
a. Evaluation Report documenting compliance with the requirements of ICC-ES AC307.
b. Details, properties, and dimensions of end anchors. Include type or size identification, and bar size(s) and grade(s) for which the end anchor is suitable.
c. Manufacturer’s installation and testing instructions.
d. Manufacturer's statement that products installed in accordance with manufacturer's recommended procedures will develop strengths and limit slip as specified in this Section.

C. Shop drawings:
1. Reinforcement shop drawings:
a. Submit drawings showing bending and placement of reinforcement required by the Contract Documents.
b. Clearly indicate structures or portions of structures covered by each submittal.
c. Shop drawings shall conform to the recommendations of the CRSI Manual of Standard Practice and ACI SP-66.
d. Use the same bar identification marks on bending detail drawings, placement drawings, and shipping tags.
e. Submittals consisting solely of reinforcing bar schedules, without accompanying placement drawings, will not be accepted unless accepted under prior written agreement with Engineer.

2. Reinforcement placement drawings:
a. Clearly show placement of each bar listed in the bill of materials, including additional reinforcement at corners and openings, and other reinforcement required by details in the Contract Documents.
b. Clearly identify locations of reinforcement with coatings (e.g., galvanized or epoxy) and with yield strength other than ASTM A615, Grade 60.
c. Show anchor bolt locations based on anchor bolt templates for approved equipment.
d. Show splice locations.
e. Showlocations of mechanical reinforcing couplers if used
f. Show locations of reinforcing bar end anchors, if used.

3. Reinforcement fabrication drawings:
a. If bend types or nomenclature differs from that recommended in the CRSI Manual of Standard Practice, provide details showing bend types and dimensional designations.
Clearly identify reinforcement with coatings and with yield strength other than ASTM A615, Grade 60.

D. Samples (when requested by Engineer):
   1. Bar supports/wire reinforcement supports: Samples of each type of chair and bolster proposed for use. Submit with letter stating where each type will be used.
   2. Precast concrete bar supports: Samples of each type of precast support proposed for use. Submit with letter stating where each will be used.

E. Test reports:
   1. Certified copy of mill test for each steel used. Show physical properties and chemical analysis.
      a. Mill test reports may be submitted as record documents at the time the reinforcement from that heat of steel is shipped to the site.
      b. In such cases, submit certificates under the shop drawing submittal number with the letter "R" (for record date) appended to the end (e.g., of the reinforcement was submitted as 03200-002-1, deliver the associated mill certificate as submittal 03200-002-1R).
   2. Mechanical reinforcing bar couplers:
      a. Current Evaluation Report confirming that couplers provide specified tension and compression strength and conform to specified limits on total slip within the coupler.
      b. Certified copy of mill tests for heat(s) of steel incorporated into the reinforcing bar couplers shipped.
      c. For threaded sleeve type couplers, heat treatment lot numbers for each shipment.
   3. Reinforcing bar end anchors:
      a. Current Evaluation Report confirming that end anchors provide specified tension strength.
      b. Certified copy of mill tests for heat(s) of steel incorporated into the materials shipped.

F. Manufacturer's instructions:
   1. Mechanical reinforcing bar couplers:
      a. Manufacturer's installation instructions.
      b. Manufacturer's instructions for confirmation testing of couplers after reinforcing bars have been inserted into the couplers.
   2. Mechanical reinforcing bar end anchors:
      a. Manufacturer's installation instructions.
      b. Manufacturer's instructions for confirmation testing of end anchors.

G. Special procedures:
   1. Welding procedures conforming to AWS D1.4 for reinforcement to be field welded.
      a. Procedures qualification record.

H. Qualifications statements:
   1. Welder qualifications.

I. Closeout documents:
   1. Field quality control and inspection reports.
   2. Field quality assurance special inspection and testing reports.

## 1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver bars bundled and tagged with identifying tags.

B. Acceptance at site:
   1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks with letter containing manufacturer's guarantee of grade.

## 1.06 SEQUENCING AND SCHEDULING

A. Bar supports:
   1. Do not place concrete until samples and product data for bar supports have been accepted by Engineer.

# PART 2 PRODUCTS

## 2.01 DESIGN AND PERFORMANCE CRITERIA

A. The drawings contain notes describing the size and spacing of reinforcement and its placement, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete, and other related information.

## 2.02 MATERIALS

A. Reinforcing bars:
   1. Provide reinforcement of the grades and quality specified, fabricated from new stock, free from excessive rust or scale, and free from unintended bends or other defects affecting its usefulness.
   2. Reinforcing bars:
      a. ASTM A615 Grade 60 deformed bars, including the following requirements, or ASTM A706 Grade 60 deformed bars.
         1) Actual yield strength based on mil tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
         2) Ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25.
         3) Minimum fracture elongation in 8 in. shall be at least 14 percent for bar size No. 3 through No. 6, at least 12 percent for bar sizes No. 7 through No. 11, and at least 10 pecent for bar sizes No. 14 and No. 18.
         4) Minimum uniform elongation shall be at least 9 percent for bar sizes No. 3 thrugh No. 10, and at least 6 percent for bar sizes No. 11, No. 14, and No. 18.
   3. Reinforcing bars designated or required to be welded:
      a. Low-alloy, ASTM A706 Grade 60, deformed bars.

B. Bar supports:
   1. Wire supports:
      a. All stainless steel bar supports:
         1) Conforming to CRSI Manual of Standard Practice recommendations for types and details, but custom fabricated entirely from stainless steel wire conforming to ASTM A493, AISI Type 316.
      b. Stainless steel protected bar supports:
         1) Conforming to CRSI Manual of Standard Practice Class 2, Type B, and consisting of bright basic wire support fabricated from cold--drawn carbon steel wire with stainless steel ends attached at the bottom of each leg.
         2) Stainless steel wire ends shall conform to ASTM A493, AISI Type 316 and shall extend at least 3/4 inch inward from the formed surface of the concrete.
      c. Bright basic wire bar supports.
         1) Conforming to CRSI Manual if Standard Practice, Class 3.
   2. Plastic supports:
      a. Manufacturers: The following or equal:
         1) Aztec Concrete Accessories.
   3. Deformed steel reinforcing bar supports:
      a. Fabricated of materials and to CRSI details recommended for typical reinforcement embedded in concrete and bent to dimensions required to provide specified clearances and concrete cover.
   4. Precast concrete bar supports ("dobies"):
      a. Pre-manufactured, precast concrete blocks with cast-in annealed steel wires, 16-gauge or heavier.
      b. Compression strength of concrete: Equal to or exceeding the compression strength of the surrounding concrete.
      c. Block dimensions:
         1) Height to provide specified concrete cover.
         2) Footprint not less than 3 inches by 3 inches, and adequate to support the weight of the reinforcement and maintain specified concrete cover without settling into the underlying surface.

C. Tie wires:
   1. General use: Black annealed steel wire, 16-gauge or heavier.

D. Welded wire fabric reinforcement:
   1. Material:
      a. Carbon steel conforming to ASTM A1064.
   2. Provide welded wire reinforcement in flat sheet form. Rolled wire fabric is not permitted.
   3. Fabric may be used in place of reinforcing bars if accepted by Engineer:
      a. Provide welded wire fabric having cross-sectional area per linear foot not less than the cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.

E. Mechanical reinforcing bar couplers and end anchors:
   1. General:
      a. Only products conforming to the requirements of ACI 318 for mechanical splices, and holding a current Evaluation Report that documents the following performance characteristics, will be considered for use.
      b. Strength of coupler: Capable of developing tension and compression strength not lower than the lesser of the following:
         1) ACI 318 "Type 2" units: In static tension and compression:
            a) Minimum 125 percent of the ASTM-specified minimum yield strength of the reinforcement being spliced or terminated.
            b) Minimum 100 percent of the ASTM-specified minimum ultimate strength of the reinforcement being spliced or terminated.
      c. Slip of reinforcing bars within coupler: Total slip of the reinforcing bars within the splice sleeve limited as follows:
         1) For bar sizes #14 and smaller, elongation between gauge points measured clear of the splice sleeve not exceeding 0.010 inches after coupler has been loaded to a tension of 30,000 pounds per square inch and load relaxed to a tension of 3,000 pounds per square inch.
      d. Fabrication:
         1) Threaded joints:
            a) Provide threaded ends designed so that cross-threading of bars will not occur during assembly.
            b) Fabricate male ends for female couplers using coupler manufacturer's bar threading equipment to ensure proper taper and thread engagement.
         2) Mark each sleeve with heat treatment lot number.
   2. Couplers: Threaded - Reinforcing bar splice at construction joints.
      a. Steel sleeve butt splice with tapered internal threads in forged or swaged head, and nailing flange for attaching to forms. Provide with matching, tapered male-threaded dowels for insertion and tightening into threaded sleeve after form removal.
         1) Provide sleeve with factory-installed plugs to prevent concrete mortar from entering internally threaded coupler.
         2) Provide optional clipped nailing flanges as required to maintain minimum specified concrete cover over surfaces of coupler.
      b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
      c. Manufacturers: One of the following or equal:
         1) Dayton Superior, DBDI Splice System.
         2) ERICO-Pentair, Lenton Form Saver.
   3. Couplers: Threaded - reinforcing bar splice:
      a. Steel sleeve butt splice with tapered internal threads at each end for joining to matching tapered male threads on reinforcing bars.
      b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC133.
      c. Manufacturers: One of the following, or equal:
         1) Dayton Superior: Taper-Lock System.
         2) ERICO-Pentair: Lenton Taper Threaded Splicing System.
   4. End anchors:
      a. Headed steel disc with tapered internal female threads for joining to matching tapered male threads on reinforcing bars.

b. Holding current Evaluation Report demonstrating acceptance under ICC-ES AC347.
c. Manufacturers: One of the following or equal:
1) Dayton Superior, D350/351 Taper-Lock End Anchor Disc.
2) ERICO-Pentair, Inc., Lenton Terminator.

## 2.03 FABRICATION

A. Shop fabrication and assembly:
1. Cut and bend bars in accordance with provisions of ACI 318 and the CRSI Manual of Standard Practice.
2. Bend bars cold. Use bending collars to develop the recommended bend radius.
3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.
4. Circumferential and radiused reinforcement: Roll to the radius required for its location in the structure before installation.
5. Bars to be fitted with mechanical couplers or mechanical end anchors:
a. Fabricate threaded ends for connections in shop using manufacturer's recommended tools. Field fabrication is not allowed.
b. Cut ends square.

# PART 3 EXECUTION

## 3.01 EXAMINATION

A. Verification of conditions:
1. Reinforcing bars and welded wire reinforcement:
a. Verify that reinforcement is new stock, free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings that will adversely affect bonding capacity when placed in the Work.
2. Welded wire fabric:
a. Verify that sheets are not curled or kinked before or after installation.

## 3.02 PREPARATION

A. Surface preparation:
1. Reinforcing bars - uncoated:
a. Clean reinforcement of concrete, dirt, oil and other coatings that will adversely affect bond before embedding bars in subsequent concrete placements.
b. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean bars having rust scale, loose mill scale, or thick rust coat.
c. Partially embedded reinforcement: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placements.

## 3.03 INSTALLATION

A. Reinforcing bars: General:
   1. Field-cutting of reinforcing bars is not permitted.
   2. Field-bending of reinforcing bars, including straightening and rebending, is not permitted.

B. Placing reinforcing bars:
   1. Accurately place bars to meet position and cover requirements indicated on the Drawings and specified. Secure bars in position.
   2. Tolerances for placement and minimum concrete cover: As listed in Table 1.

**Table 1 - Reinforcement Placing Tolerances**

| Member | Tolerance on Reinforcement Location (1) | Tolerance on Minimum Concrete Cover (1,2) |
|---|---|---|
| Slabs, beams, walls and columns except as noted below: | | |
| 10 inches thick and less | ± 3/8 inch | - 3/8 inch |
| More than 10 inches thick | ± 1/2 inch | - 1/2 inch |
| Formed soffits: | As noted above | - 1/4 inch |
| Longitudinal location of bends and ends of reinforcement: | | |
| Conditions not listed below: | ± 2 inches | - 1/2 inch |
| At discontinuous ends of brackets and corbels | ± 1/2 inch | - 1/4 inch |
| At discontinuous ends of other members: | ± 1 inch | - 1/2 inch |

Notes:
(1) ± indicates "plus or minus;" - indicates "minus;" + indicates "plus."
(2) Tolerance on cover is limited as noted, but decrease in cover shall not exceed one third of the minimum cover indicated on the Drawings.

   3. Spacing between bars:
      a. Minimum clear spacing between bars in a layer:
         1) As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
      b. Minimum clear spacing between bars in 2 or more parallel layers:
         1) Place bars in upper layers directly above bars in lower layers.
         2) Minimum spacing between layers: As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
      c. Limits on minimum clear spacing between bars also applies to the clear spacing between a lap splice and the adjacent bars and/or lap splices.
   4. Lap splices for bars:
      a. Lap splice locations and lap splice lengths: as indicated on the Drawings. Where lap lengths are not indicated, provide in accordance with ACI 318.

b. Unless otherwise specifically indicated on the Drawings (and noted as "non-contact lap splice"), install bars at lap splices in contact with each other and fasten together with tie wire.
c. Where bars are to be lap spliced at concrete joints, ensure that bars project from the first concrete placement a length equal to or greater than minimum lap splice length indicated on the Drawings.
d. Stagger lap splices where indicated on the Drawings.
e. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318.

C. Reinforcing supports:
1. Provide supports of sufficient numbers, sizes, and locations to maintain concrete cover, to prevent sagging and shifting, and to support loads during construction without displacement and without gouging or indentation into forming surfaces.
a. Quantities and locations of supports shall not be less than those indicated in ACI SP-66 and the CRSI Manual of Standard Practice.
2. Do not use brick, concrete masonry units, concrete spalls, rocks, wood, or similar materials for supporting reinforcement.
3. Do not use "give away bars" that have less cover than that required by the Contract Documents. Do not adjust the location of reinforcement required by the Contract Documents to provide cover for give away bars.
4. Provide bar supports of height required to maintain the clear concrete cover indicated on the Drawings.
5. Provide bar supports at formed vertical faces to maintain the clear concrete cover indicated on the Drawings.
6. Schedule of reinforcement support materials: Provide bar supports as indicated in Table 2.

**Table 2 - Reinforcement Support Materials**

| Case | Location | Material |
|---|---|---|
| a. | Concrete placed over earth and concrete seal slabs ("mud mats"): | Precast concrete bar supports or stainless steel wire supports on stainless steel plates. |
| b. | Concrete placed against forms and exposed to water or wastewater process liquids (whether or not such concrete received additional linings or coatings): | All stainless steel bar supports. |
| c. | Concrete placed against forms and exposed to earth, weather, frequent washdown, or groundwater in the finished work | All stainless steel bar supports. |
| d. | Concrete placed against forms and exposed to interior equipment/piping areas in the finished work | Stainless steel protected bars supports. |
| e. | Between mats of reinforcement, and fully embedded within a concrete member | Bright basic wire bars supports, or deformed steel reinforcing bars. |

D. Tying of reinforcing:
   1. Fasten reinforcement securely in place with wire ties.
   2. Tie reinforcement at spacings sufficient to prevent shifting.
      a. Provide at least 3 ties in each bar length. (Does not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity).
   3. Tie slab bars at every intersection around perimeter of slab.
   4. Tie wall bars and slab bar intersections other than around perimeter at not less than every fourth intersection, but at not more than the spacing indicated in Table 3:

**Table 3 - Maximum Spacing of Tie Wires for Reinforcement**

| Bar Size | Slab Bar Spacing (inches) | Wall Bar Spacing (inches) |
|---|---|---|
| Bars Number 5 and Smaller | 60 | 48 |
| Bars Number 6 through Number 9 | 96 | 60 |
| Bars Number 10 and Number 11 | 120 | 96 |

   5. After tying:
      a. Bend ends of wires inward towards the center of the concrete section. Minimum concrete cover for tie wires shall be the same as cover requirements for reinforcement.
      b. Remove tie wire clippings from inside forms before placing concrete.

E. Welded wire fabric reinforcement:
   1. Install only where indicated on the Drawings or accepted in advance by Engineer.
   2. Install necessary tie wires, spacing chairs, and supports to keep welded wire fabric at its designated position in the concrete section while concrete is being placed.
   3. Straighten welded wire fabric to make sheets flat in the Work.
   4. Do not allow wire fabric to drape between supports unless such a configuration is specifically indicated on the Drawings.
      a. If fabric is displaced during placement of concrete, make provisions to restore it to the designated location using methods acceptable to Engineer.
   5. Bend welded wire fabric as indicated on the Drawings or required to fit Work.
   6. Lap splice welded wire fabric as indicated on the Drawings.
      a. If lap splice length is not indicated, splice in accordance with ACI 318, but not less than 1 1/2 courses of fabric or 8 inches minimum. Tie laps at ends and at not more than 12 inches on center.

F. Welding reinforcing bars:
   1. Weld reinforcing bars only where indicated on the Drawings or where acceptance is received from Engineer prior to welding.
   2. Perform welding in accordance with AWS D1.4 and welding procedures accepted by Engineer.
      a. Conform to requirements for minimum preheat and interpass temperatures.
   3. Submit:
      a. Welding procedures specification.

b. Procedures qualification record.
c. Welder qualification test record.

4. Do not tack weld reinforcing bars except where specifically indicated on the Drawings.

G. Reinforcing bar mechanical couplers and end anchors:
1. Install only at locations indicated on the Drawings or where prior approval has been obtained from Engineer.
2. Install in accordance with manufacturer's instructions and requirements of Evaluation Report.
a. Make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.
b. After assembly of the splice, tighten using torque load not less than that recommended by the manufacturer.
3. Unless greater cover is indicated on the Drawings, provide clear cover from surface of concrete to outside face of couplers that is not less than the minimum concrete cover specified for typical reinforcement.
a. If cover is less than required, contact Engineer for evaluation of conditions before modifying locations of bars or placing concrete.
b. Modifications to maintain or provide required concrete cover, such as addition of concrete ; re-positioning of stirrups, ties, etc., may be completed only after approval by Engineer.

## 3.04 FIELD QUALITY CONTROL

A. Provide quality control for the Work of this Section as specified in Section 01450 - Quality Control.

B. Field inspections and testing:
1. Submit records of inspections and testing to Engineer in electronic format within 24 hours after completion.

C. Manufacturer's services:
1. Furnish manufacturer's technical representative to conduct jobsite training regarding proper storage, handling, and installation of mechanical reinforcing bar couplers and bar end anchors for personnel who will perform the installation. Engineer may attend training session.

## 3.05 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01450 - Quality Control.

B. Special inspections and tests:
1. Provide as specified in Section 01455 - Regulatory Quality Assurance.
2. Frequency of inspections:
a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Building Code specified in Section 01410 - Regulatory Requirements.
3. Preparation:
a. Review Drawings and Specification for the Work to be observed.
b. Review approved submittal sand shop drawings.

4. Inspections: Special inspection shall include, but is not limited to, the following items.
    a. Reinforcement: General:
        1) Type (material) and location of reinforcement supports.
        2) Bar material/steel grade and bar size.
        3) Location, placement, and spacing of bars.
        4) Clear concrete cover over reinforcement.
        5) Lap splice: Location and lap length. Bars within tolerances for contact (unless non-contact splice is indicated on the Drawings.)
        6) Bar hooks and development lengths embedded within concrete sections as indicated on the Drawings.
        7) Reinforcement tired in position and tie wire legs turned inward toward the center of the concrete section.
    b. Reinforcement: Welding:
        1) Inspector qualification and inspections shall be in accordance with the requirements of AWS D1.4.
        2) Provide periodic inspection for:
            a) Weldability of reinforcement other than ASTM A706.
            b) Single pass fillet welds with thickness less than or equal to 5/16 inch.
        3) Provide continuous inspection for:
            a) Other welds.
            b) Welds at mechanical reinforcing bar couplers and end anchors.
        4) In addition to visual inspection, Owner may inspect reinforcing bar welds by other methods, including radiographic inspection.
5. Mechanical reinforcing bar couplers and end anchors:
    a. Special inspection shall include, but is not limited to, the following items:
        1) Coupler and end anchor model and identification.
        2) Couplers and end anchors are installed in accordance with the requirements of the Engineering Report for each product.
        3) Confirmation of the following:
            a) Grade and size of reinforcing bars.
            b) Position of couplers and end anchors.
            c) Insertion length of reinforcement.
            d) Tightening of bars in the couplers and end anchors.
6. Records of inspections:
    a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
    b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspections.

## 3.06 NON-CONFORMING WORK

A. Before placing concrete, adjust or remove and re-install reinforcement to conform to the requirements of the Contract Documents.

END OF SECTION

# SECTION 03212

# REINFORCING BAR COUPLERS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Reinforcing bar couplers.

### 1.02 SYSTEM DESCRIPTION

A. Performance requirements for reinforcing bar coupler:
   1. The splicing system and materials used in accordance with the manufacturer's procedures shall develop in tension or compression not less than 125 percent of the specified yield strength of the bar and 100 percent of the tensile strength of the bar.

### 1.03 SUBMITTALS

A. Submit the following information for each shipment of splice material:
   1. The type or series identification of the splice material. For threaded sleeve-type, the heat treatment lot number.
   2. The bar grade and size number to be spliced.
   3. A copy of the manufacturer's catalog giving complete data on the splice material and procedures.
   4. A statement that the splicing systems and materials used in accordance with the manufacturer's procedures will develop the strength requirements, the total slip requirements, and other requirements in these specifications.

## PART 2 PRODUCTS

### 2.01 MANUFACTURED UNITS

A. Reinforcing bar couplers: Mechanical butt splices of the threaded sleeve type or the swaged sleeve type, at the option of the Contractor:
   1. Threaded sleeve type of reinforcing bar coupler:
      a. Steel splice sleeve with tapered interior threads that join the reinforcing bars with matching tapered threads.
      b. Taper threads to such a degree that cross threading will not occur during assembly.
      c. Mark each splice sleeve with the heat treatment lot number.
   2. Swaged sleeve type of reinforcing bar coupler: Seamless steel sleeve applied over the ends of the reinforcing bars and swaged to the bars by means of a hydraulic press.

B. Couplers shall be Lenton Form Saver by Erico Products, Dowel Bar Splicer System by Dayton/Richmond, or equal.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Use reinforcing bar couplers only where indicated on the Drawings or accepted by the Engineer.

B. Install in accordance with the manufacturer's instructions, except as modified in this Section.
   1. Make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.
   2. After completion of assembly of the splice, tighten splice to a torque value of not less than recommended by the manufacturer.

C. Cut ends of reinforcing bars to be spliced nominally square.

D. Provide clear cover over reinforcing bar couplers of not less than indicated on the Drawings or specified for the reinforcing bars when measured from the surface of the concrete to the outside of the coupler sleeve.
   1. With written acceptance of the Engineer, adjust stirrups, ties, and other reinforcement and place additional reinforcement, if necessary, to provide planned clear cover over reinforcement.

END OF SECTION

**SECTION 03300**

**CAST-IN-PLACE CONCRETE**

**TABLE OF CONTENTS**

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Cast-in-place concrete.

B. The requirements of this Section will require advance planning for preparation and testing of trial batches. Review the mix design and testing requirements carefully, and schedule preparations and testing with sufficient time to complete tests, to obtain Engineer's review of mixes and testing results, and to complete revisions and re-testing if required.

### 1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
   2. CODE-350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
   3. PRC-212.3 - Report on Chemical Admixtures for Concrete.
   4. PRC-302.1 - Guide to Concrete Floor and Slab Construction.
   5. PRC-305 - Guide to Hot Weather Concreting.
   6. PRC-306 - Guide to Cold Weather Concreting.

B. ASTM International (ASTM):
   1. C29 - Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C33 - Standard Specification for Concrete Aggregates.
   4. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   5. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
   6. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   7. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   8. C94 - Standard Specification for Ready-Mixed Concrete.
   9. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
   10. C117 - Standard Test Method for Materials Finer that 75-m (No. 200) Sieve in Mineral Aggregates by Washing.
   11. C123 - Standard Test Method for Lightweight Particles in Aggregate.
   12. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   13. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   14. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

15. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
16. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
17. C150 - Standard Specification for Portland Cement.
18. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
19. C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
20. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
21. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
22. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
23. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
24. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
25. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
26. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
27. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
28. C494 - Standard Specification for Chemical Admixtures for Concrete.
29. C595 - Standard Specification for Blended Hydraulic Cements.
30. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
31. C702 - Standard Practice for Reducing Samples of Aggregate to Testing Size.
32. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
33. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
34. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
35. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
36. C1293 - Standard Test Method for Determination of Length Change of Concrete due to Alkali-Silica Reaction.
37. C1602 - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
38. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
39. D29 - Standard Practice for Determining Volatile and Nonvolatile Content of Cellulosics, Emulsions, Resin Solutions, Shellac, and Varnishes.
40. D75 - Standard Practice for Sampling Aggregates.
41. D2103 - Standard Specification for Polyethylene Film and Sheeting.
42. D3665 - Standard Practice for Random Sampling of Construction Materials.
43. D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

C. National Ready-Mixed Concrete Association (NRMCA).

## 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: The sum of sodium oxide and potassium oxide calculated as sodium oxide.
   2. Alkali Load: Amount of alkalis contributed by the Portland cement in a concrete mixture, expressed in pounds per cubic yard ($lb/yd^3$) and calculated by multiplying the Portland 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.
   3. Architectural Concrete: Concrete surfaces that will be exposed to view in the finished work.
      a. For purposes of this Section, includes only those surfaces that receive paint or coatings.
      b. Exposed concrete surfaces in open basins, channels, and similar liquid containing structures: Surfaces will be considered exposed to view if located above the water line as defined in Section 03366 - Concrete Finishes.
      c. Exterior concrete surfaces with portions above and below grade: Surface will be considered exposed to view of located above the grade line as defined in Section 03366 - Concrete Finishes.
   4. Average Daily Temperature: Calculated by summing hourly measurements of air temperature in the shade at the face of the concrete and dividing that sum by 24. In calculating the sum of the temperatures recorded, any measurement less than 50 degrees Fahrenheit shall be recorded as 0 degrees Fahrenheit and included in the sum.
   5. Cementitious Materials: Portland cement or blended cement and supplementary cementitious materials.
   6. Class of Concrete: Refers to a mix with characteristics, proportions, and constituents (including a specific combination of admixtures) as specified in this Section.
      a. Any change in the source or characteristics of constituent materials, in the proportions of materials, or in the admixtures included in a mix shall be considered as creating a new and separate class of concrete.
      b. Any mix to be placed by pumping shall be considered as creating a new and separate class of concrete.
   7. Cold Weather: Includes one or more of the following conditions:
      a. Current air temperature is 45 degrees Fahrenheit and falling.
      b. Air temperature during the first 24 hours after placement is expected to fall into the range of 45 degrees Fahrenheit to 40 degrees Fahrenheit.
      c. A period when, for more than 3 consecutive days, the following conditions exist:
         1) The average daily air temperature drops below 40 degrees Fahrenheit.
         2) The air temperature is not greater than 50 degrees Fahrenheit for more than one-half of any consecutive 24-hour period.
   8. Cold Weather Concreting: Operations for placing, finishing, curing, and protecting concrete during cold weather.
   9. Green Concrete: Concrete that has not yet achieved 100 percent of the minimum specified compressive strength, f'c, for that mix.

10. Hairline Crack: Crack with a crack width of less than 4 thousandths of an inch (0.004 inches).
11. Hot Weather: Any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.2 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and in this Section, Attachment A - Menzel Formula and Nomograph.
12. Hot Weather Concreting: Operations for placing, finishing, curing, and protecting concrete during hot weather.
13. Paste Content: The total concrete volume minus the volume of aggregate, expressed as a percentage of total volume. Paste volume includes volume of cementitious materials, water, air, admixtures materials, and any fibers.
14. Supplemental Cementitious Material: Inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

## 1.04 DELEGATED DESIGN

A. Provide Delegated Design for the following Work, based on the requirements of this Section.
   1. Concrete mix designs.

## 1.05 SUBMITTALS

A. General:
   1. Data for concrete mixes and mix constituents supplied to the Work shall be coordinated through a single supplier.
   2. A maximum of 2 mix designs will be reviewed by the Engineer for each class of concrete required.
      a. Review of additional mix designs shall be at the expense of the Contractor.

B. Product data:
   1. Submit data completely describing products and demonstrating compliance with the requirements of this Section.
   2. Data for all products in the mix for each class of concrete shall be submitted concurrently with that mix design.
   3. Admixtures:
      a. For each admixture included in concrete mixes, submit manufacturer's product data demonstrating compliance with standards specified.
      b. If air entraining admixture requires test method other than ASTM C173 to accurately determine air content, make special note of requirements in Submittal.
   4. Curing compound: Submit complete data on proposed compound.

C. Design data:
   1. Concrete mix designs:
      a. Submit full details, including mix design calculations and plots, for concrete mixes proposed for use for each class of concrete.
      b. Include mix design calculations of proportions by both weight and volume.
      c. Determine and include the alkali load of the proposed mix.

d. Include information on correction of batching for varying moisture contents of fine aggregate.
e. Submit source quality test records with mix design Submittal.
f. Provide calculations demonstrating that the mixes proposed provide the required average compression strength of concrete (f'cr) based on source quality test records.
g. For each Class A mix design submitted, plot the mix design Attachment B - Coarseness Factor Chart and submit.
h. For each Class A mix design submitted, plot the combined aggregate gradation on the chart Attachment C - Combined Aggregate Gradation Chart and submit.

D. Concrete mixes - Trial batches:
1. Drying shrinkage test results.
a. Submit results of testing.
b. Submit test specimens from drying shrinkage tests for trial batches.
1) Submit specimens from each mix accepted by Engineer.
2) Using indelible marker, clearly label each specimen with concrete class, trial batch mix designator, and specimen number.
2. Compression strength test results.
a. Submit results of testing. Provide data for each cylinder tested.
b. Submit data indicating trial batch mix designator, slump, and specimen number for each test cylinder.
c. Submit test specimens from compression strength tests for trial batches.
1) Submit 2 cylinders from each mix accepted by Engineer.
2) Using indelible marker, clearly label each cylinder with concrete class, trail batch number, and specimen number.
3. If there is any change in suppliers or in quality of concrete mix constituents, submit new test data.

E. Test reports:
1. Dated not more than 24 months prior to the date of Submittal.
2. Aggregate:
a. Submit certified copies of commercial laboratory tests proposed for use in concrete.
b. Sieve analyses:
1) During construction, submit sieve analyses of coarse, intermediate, fine, and combined aggregates used any time there is a change in supplier, or a significant change in the character and/or grading of materials, and when requested by the Engineer.
c. Aggregates - coarse:
1) Physical properties:
a) Sieve analysis.
b) Percentage of particles having flat and/or elongated characteristics.
c) Abrasion loss.
d) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles content.
b) Materials finer than 200 sieve (percentage).
c) Shale and chert content.

d) Coal and lignite content.
3) Alkali reactivity.
d. Aggregates - Intermediate:
1) Physical properties:
a) Sieve analysis.
b) Percentage of particles having flat and/or elongated characteristics.
c) Abrasion loss.
d) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles content.
b) Chert and shale content.
c) Coal and lignite content.
d) Materials finer than No. 200 sieve.
3) Alkali reactivity.
e. Aggregates - Fine:
1) Physical properties:
a) Sieve analysis and fineness modulus.
b) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles (percentage).
b) Materials finer than No. 200 sieve (percentage).
c) Coal and lignite (percentage).
d) Shale and chert.
e) Organic impurities (“Color” as determined by ASTM C40).
3) Alkali reactivity.
f. Aggregates - Combined:
1) Test combined gradation for the following sieve sizes: 1.5 inches, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, Number 4, Number 8, Number 16, Number 30, Number 100, Number 200.
2) Bulk density in accordance with ASTM C29.
3) Void content in accordance with ASTM C29.
4) Submit at:
a) Initial mixture design Submittal.
b) Intervals of not more than 4 weeks.
c) Any time there is a change in character or grading of constituent materials.
d) When requested by the Engineer.

3. Cement:
a. Mill tests, including alkali content measured as equivalent alkalis, for each shipment of cement included in the Work.
1) During construction, submit mill certificates for cement being used at intervals of not more than 90 days, any time there is a change in supplier or a significant change in the character of the materials, and when requested by the Engineer.

4. Supplemental cementitious material:
a. Fly ash: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C618 and this Section.
1) Include supplier's report certifying the total alkali content of the material, expressed as equivalent percentage of sodium oxide ($Na_2Oe$).

F. Certificates:
   1. Current NRMCA certification for all plants and trucks that will be used to supply concrete.

G. Source quality control Submittals:
   1. Truck batch tickets for each load of concrete delivered to the site, whether accepted or rejected.
   2. Concrete supplier's quality control plan. Include the following elements, at a minimum:
      a. Names and qualifications of key quality control personnel:
         1) Quality control manager.
         2) Testing and inspection personnel.
      b. Names and qualifications of testing laboratories:
         1) Each laboratory shall hold current accreditation from the AASHTO Accreditation Program, or other accreditation program acceptable to the Engineer, for each test performed.
      c. Example forms for: Inspection reports, certificates of compliance, and test results.
      d. Quality control procedures: Method and frequency of performing each procedure, including inspections and materials testing. At a minimum, the plan shall include:
         1) Daily testing of aggregate gradation.
         2) Monthly testing of cement quality.
         3) Monthly testing of fly ash quality.
      e. Procedures to control quality characteristics, including standard procedures to address properties outside the specified operating limits, and example reports to document non-conformances and corrective actions taken. Include procedure for notifying Contractor and Engineer of non-conformances.
      f. Procedures for verifying that:
         1) Materials are properly stored during concrete batching operations.
         2) Batch plants have the ability to maintain concrete consistency during periods of extreme heat and of low temperatures.
         3) Admixtures are dispensed in the correct dosages within the accuracy requirements specified.
         4) Delivery trucks have a valid NRMCA certification card.
      g. Procedures for verifying that weighmaster certificate for each load of concrete shows:
         1) Cement and supplementary materials are from sources designated in the approved Submittals.
         2) Concrete as-batched complies with the constituent weights designated in the approved Submittals.
         3) Corrections for aggregate moisture are being correctly applied.
         4) Any mix water withheld from the batch.
      h. Procedures for visually inspecting concrete during discharge.

H. Field quality control Submittals:
   1. Contractor's notifications of readiness for concrete placement.

2. Contractor's reports of field quality control testing.
    a. Include with each report the concrete batch ticket number and identification numbers for associated cylinders used for compressive strength testing.
    b. Testing results for slump, temperature, unit weight, and air entrainment.
    c. Testing results for compressive strength at 7 and 28 days, and for any compressive strength tests after 28 days.
    d. Note on batch ticket the amount of water that was withheld and the maximum amount that can be added on site as “Max add water.” Record on the batch ticket the volume of water actually added at site.
    e. Note on the batch ticket the concrete mix classification as defined in Table 3 of this Section.

I. Special procedure Submittals:
    1. Sequence of concrete placing:
        a. Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements. Submittal shall include plans sections and details to address all pours.
    2. Cold weather concreting plan.
    3. Hot weather concreting plan.
    4. Repair of defective concrete: Submit mix design for repair materials to be used.

## 1.06 QUALITY ASSURANCE

A. Pre-installation meetings:
    1. Schedule and conduct pre-installation meeting at least 10 days prior to batching and placing of concrete.
        a. Provide additional meetings if necessary, to discuss specific concrete Submittals, mixes, or placing and curing conditions.
        b. Notify Engineer of location and time of each conference.
    2. Required attendees:
        a. Contractor including Contractor's superintendent and key personnel.
        b. Concrete supplier.
        c. Technical representative(s) of supplier(s) of concrete admixtures.
        d. Subcontractor(s) providing pumping, placing, finishing, and curing.
        e. Subcontractor(s) providing embedded items (structural embedded plates, electrical conduit).
        f. Sampling and testing personnel.
        g. Engineer.
        h. On-site inspectors representing Engineer.
        i. Other persons deemed by the Engineer and the Contractor to be critical to the quality and efficiency of the Work.
    3. Agenda:
        a. Review of requirements of Drawings and Specifications.
        b. Project and product safety requirements.
        c. Discussion of points of interface and coordination between various trades or products to be used in the Work.
        d. Contractor's schedule for cast-in-place concrete work.
        e. Mix designs, mix tests, and Submittals.
        f. Admixture types, dosing, performance, requirements for monitoring, and limits on dosing or re-dosing at the site.

g. Placement and consolidation methods, techniques, and equipment and the effects of those methods on form pressures.
h. Slump and limits on placing time or conditions to maintain placeability.
    1) Field adjustment of slump and air content.
i. Procedures for finishing, curing, and retention of moisture during these operations.
j. Procedures and protection for hot and cold weather conditions.
k. Requirements and coordination for inspections.
    1) Responsibility for test specimen curing and storage.
    2) Distribution of test reports.
l. Other Specification requirements requiring coordination between parties to the work.

4. Prepare and submit minutes of the pre-installation meeting as specified in Section 01312 - Project Meetings.

## 1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
1. Deliver, store, and handle concrete materials in manner that prevents damage and inclusion of foreign substances.
2. Deliver and store packaged materials in original containers until ready for use.
3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.

B. Acceptance at site:
1. Reject material containers or materials showing evidence of water or other damage.
2. Concrete mixes: Do not accept or incorporate into the Work concrete mixes that do not comply with the specified requirements for water content, slump, temperature, and air content.

## 1.08 PROJECT CONDITIONS

A. Cold weather concreting: During periods of cold weather as defined in this Section, implement cold weather concreting procedures in this Section.

B. Hot weather concreting: During periods of hot weather as defined in this Section, implement hot weather concreting procedures in this Section.

## 1.09 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in a manner that completes all placing operations from one construction, contraction, or expansion joint to another construction, contraction, or expansion joint.

B. Joints at each end of the placement shall be as indicated on the Drawings, or as identified and accepted in advance by the Engineer.

## PART 2 PRODUCTS

### 2.01 DESIGN AND PERFORMANCE CRITERIA

A. It is the intent of this Section to secure, for every part of the Work, concrete with a homogeneous mixture, that, when hardened, will have required strength, watertightness, and durability.

B. It is the intent of this Section to procure a workable, low-shrinkage concrete mix that maximizes aggregate content and minimizes paste content.

C. Performance requirements:
   1. General:
      a. Except as otherwise specified, provide concrete composed of Portland cement or blended cement, supplemental cementitious materials, aggregate, admixtures and water, proportioned and mixed to produce a plastic, workable mixture in accordance with requirements of this Section, and suitable to specific conditions of placement.
      b. Proportion aggregates to produce an optimized gradation of aggregate that combines fine, intermediate, and coarse aggregate in well-graded proportions that maximizes the aggregate content and minimizes the paste content of the mix. Gradation should maximize long-term durability and strength of the concrete mixture.
      c. Durability requirements will be deemed to be satisfied when:
         1) Mixture is proportioned with a well-graded combined aggregate.
         2) Specified water-cement ratio is satisfied.
         3) Concrete contains the specified range of air content.
         4) Maximum specified paste content is satisfied.
      d. Proportion materials in a manner that will secure the lowest cement content, water-cementitious materials ratio, and paste volume that is consistent with good workability that provides a plastic and cohesive mixture, and that provides a slump that is within the specified range.
      e. Construction and expansion joints have been positioned in structures as indicated on the Drawings, and curing methods have been specified, for purpose of to reduce the number and size of cracks, resulting from normal expansion and contraction expected from the concrete mixes specified.
      f. Remove and replace, or repair as specified in this Section, non-conforming work and surfaces with cracks, voids and honeycombs, or surface wetness.
   2. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI CODE-318, and ACI CODE-350.

### 2.02 MATERIALS - GENERAL

A. Water and ice:
   1. Water for concrete mixes, for washing aggregate, and for curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances from a municipal potable water source.
   2. Do not use water from concrete production operations, or combined water from concrete production operations as defined in ASTM C1602.

## 2.03 MATERIALS - CONCRETE MIX CONSTITUENTS

A. Water and ice:
   1. As specified in the preceding paragraphs.

B. Cementitious materials:
   1. Portland cement:
      a. In accordance with ASTM C150.
         1) Type II.
      b. Single source: To provide uniformity of appearance, for each structure use only one source, type, and brand of Portland cement for walls and slabs that will be exposed in the finished work.
         1) Confirm adequate supply of cement over duration of project before making trial batches or beginning concrete placements.
      c. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.
   2. Blended hydraulic cement:
      a. In accordance with ASTM C595:
         1) Type IL (MS).
      b. [Single source: To provide uniformity of appearance and quality, for each structure use only 1 source, type, and brand of cement.
      c. Confirm adequate supply of cement over duration of project before making trial batches or beginning concrete placements.
      d. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.

C. Supplementary cementitious materials:
   1. Fly ash:
      a. Class C or Class F fly ash in accordance with the requirements of ASTM C618, except as modified in this Section.
         1) Class C may be used in concrete made with Type II Portland cement.
         2) Class F required if used in concrete mixes containing aggregates classified as potentially reactive based on ASTM C1293 or ASTM C1260.
            a) CaO content: Less than 18 percent.
      b. Loss on ignition: Not exceeding 3 percent.
      c. Replace Portland cement at ratio of 1.0 pound fly ash for each pound of cement, up to minimum and maximum replacement as specified in “Requirements for Mix Proportioning.”

D. Admixtures:
   1. General:
      a. Do not include admixtures, other than those specified, unless written acceptance has been obtained from the Engineer during Submittal of mix designs.
      b. Admixtures shall be compatible with concrete constituents and with other admixtures.
         1) All admixtures in a given mix shall be products of the same manufacturer to ensure compatibility.
         2) Admixture manufacturers: One of the following, or equal.
            a) Euclid Chemical.

b) GCP Applied Technologies (formerly W.R. Grace).
c) Master Builders Solutions/Sika.
d) Sika Corp.

c. Do not use admixtures containing chlorides, calculated as chloride ion, in excess of 0.5 percent by weight of cement.
d. Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
e. Admixtures used shall be the same products used in concrete trial batches, or the same products used in concrete represented by submitted field test records.

2. Air entraining admixture (AEA):
   a. In accordance with ASTM C260 and dosed to provide entrained air percentages specified in this Section.
   b. Provides entrained air as bubbles, evenly dispersed at the time of placement and during curing.
3. Water reducing admixture(WRA):
   a. May be used at the Contractor's option.
   b. Conforming to ASTM C494, Type A (water-reducing).
      1) ASTM C494, Type D (water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
   c. Not containing air-entraining agents.
   d. Liquid form before adding to the concrete mix.
4. High-range, water-reducing admixture (“superplasticizer”) (HRWR):
   a. In accordance with ASTM C494, Type F (high-range, water-reducing).
      1) ASTM C494, Type G (high-range, water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
   b. Producing non-segregating, plasticized concrete with little bleeding and the physical characteristics of low water/cement ratio concrete.
   c. Admixture shall maintain treated concrete in a plasticized state for not less than 1 hour.
5. Set-controlling admixtures:
   a. Shall not be used without prior acceptance from Engineer.
   b. Retarders, when permitted:
      1) In accordance with ASTM C494, Type B, D or G.
   c. Accelerating admixtures, when permitted:
      1) In accordance with ASTM C494, Type C or E.

E. Coloring admixtures:
   1. Conduit encasement coloring agent:
      a. Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
      b. Manufacturers: One of the following, or equal:
         1) Davis Co., #100 Utility Red.
         2) Euclid Chemical Co., Increte Division, “Colorcrete Brick Red”.
         3) I. Reiss Co., Inc., equivalent product.
      c. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.

F. Aggregate:
   1. General:
      a. Provide concrete aggregates that are sound, graded as specified, and free of deleterious material in excess of allowable amounts specified.
      b. Provide aggregates to produce in place concrete with unit weight as follows:
         1) Normal weight concrete: Not less than 140 pounds per cubic foot.
      c. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
      d. Do not use aggregate recycled from fresh concrete returned to the batching facility.
   2. Alkali-silica reactivity:
      a. Provide aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 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.
   3. Fine aggregate:
      a. Material graded such that 95 to 100 percent of material passes the No. 4 (4.75 mm) sieve, when sampled in accordance with ASTM D75 and D3665, and tested in accordance with ASTM C136.
      b. Provide fine aggregate consisting of clean, natural sand, or sand prepared from crushed stone or crushed gravel.
      c. In accordance with ASTM C33 requirements for grading, deleterious substances, soundness, and alkali reactivity, except as modified in the following paragraphs:
         1) Grading: For sieve sizes listed in ASTM C33 for fine aggregate, not more than 45 percent passing any sieve and retained on the next consecutive sieve.
         2) Deleterious substances: Not in excess of the percentages by weight specified in Table 1 of this Section.

**Table 1: Fine Aggregate, Limits on Deleterious Substances**

| Item | Test Method | Percent (maximum) |
|---|---|---|
| Materials finer than No. 200 sieve(2) | ASTM C117 | 3.00(2) |
| Clay lumps and friable particles | ASTM C142 | 1.00 |
| Lightweight particles (SG < 2.40) | ASTM C123 | 1.00 |
| • Chert or shale(1) | ASTM C295 | 1.00(1) |
| Coal and lignite | ASTM C123 | 0.50 |

Notes:
(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage of lightweight particles (sum of shale, chert, coal and lignite) not greater than 1.00, testing under ASTM C295 will not be required.
(2) For manufactured sand, if material finer than the No. 200 sieve consists of crusher dust and the aggregate is essentially free of clay or shale, maximum percentage may be increased to 5.0 percent.

3) Organic impurities: Free of injurious amounts of organic matter and producing a supernatant liquid with color not darker than “standard color” when tested in accordance with ASTM C40.
4) Soundness: In accordance with requirements of ASTM C33 when tested in accordance with ASTM C88 using sodium sulfite solution.

4. Intermediate aggregate:
   a. Material graded such that 90 to 100 percent of material passes the 3/8-inch sieve, and not more than 5 percent of material passes the No. 50 (300 µm) sieve, when sampled in accordance with ASTM D75 and D3665 and tested in accordance with ASTM C136.
   b. Requirements for maximum percentage of impurities, abrasion loss, and soundness: As specified for coarse aggregate.
5. Coarse aggregate:
   a. Materials graded such that not more than 10 percent of material passes the 3/8-inch sieve, when sampled in accordance with ASTM D75 and D3665 and tested in accordance with ASTM C136.
   b. Consisting of gravel, crushed gravel, crushed stone, or a combination of these materials having clean, hard, durable particles free from calcareous coatings, organic matter, or other deleterious substances.
   c. Conforming to the requirements of ASTM C33, Class 4S for physical properties, deleterious substances, and alkali reactivity, except as modified in the following paragraphs:
      1) Grading:
         a) Size number as specified in ASTM C33, and as indicated in Table 3 of this Section, except as otherwise specified or accepted by the Engineer.
         b) Weights of flat or elongated particles (particles having a length greater than 3 times average width or thickness) not exceeding 15 percent when tested in accordance with ASTM D4791.
      2) Deleterious substances: Not in excess of the percentages by weight specified in Table 2 of this Section and having total of all deleterious substances exceeding 2 percent.

**Table 2: Coarse Aggregate, Limits on Impurities**

| Item | Test Method | Percent (maximum) |
|---|---|---|
| Clay lumps and friable particles | ASTM C142 | 0.50 |
| Lightweight particles (SG < 2.40) | ASTM C123 | 1.25 |
| • Chert or shale(1) | ASTM C295 | 1.00(1) |
| Materials finer than No. 200 sieve | ASTM C117 | 0.50(2) |
| Coal and lignite | ASTM C123 | 0.25 |

Notes:
(1) ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage (sum of shale, chert, coal and lignite) not greater than 1.25, testing under ASTM C295 will not be required.
(2) When material finer than No. 200 sieve consists of crusher dust, maximum percentage may be increased to 1.00 percent. When mix design complies with provisions of ASTM C33, Table 4, footnote C, the maximum percentage may be increased in accordance with the equation in footnote C, up to a maximum of 1.5 percent.

3) Abrasion loss: Loss not greater than 45 percent after 500 revolutions when tested in accordance with ASTM C131.
4) Soundness: Loss not greater than 10 percent when tested in accordance with ASTM C88 using sodium sulfate solution.

## 2.04 MATERIALS FOR PLACING, CURING AND FINISHING

A. General:
1. Materials shall be compatible with concrete and with other materials.

B. Cement grout:
1. Use: For spreading over surface of construction and cold joints in concrete before placing additional concrete above those joints.
2. As specified in Section 03600 - Grouting.

C. Concrete sealer:
1. As specified in Section 03366 - Concrete Finishes.
2. Not for use in water-containment structures.

D. Evaporation retardant:
1. Use: For mitigating surface moisture evaporation from freshly placed concrete during rapid drying conditions. Placed after screeding.
2. Waterborne, monomolecular, spray-applied compound, with fugitive dye to indicate coverage.
3. Manufacturers: One of the following, or equal:
a. Euclid Chemical Co., Eucobar.
b. Master Builders Solutions/Sika, MasterKure ER 50.

E. Plastic membrane for curing:
1. Polyethylene film: In accordance with ASTM C171.
2. Properties:
a. Color: White.
b. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
c. Loss of moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

F. Sprayed membrane curing compound:
1. Combination curing and sealing products (“cure and seal”) will not be permitted.
2. Properties:
a. Clear type with fugitive dye conforming with ASTM C309, Type 1D and containing no wax, paraffin, or oils.
b. For concrete placed or cured during hot weather, curing compound shall be as specified, except that:
1) It shall include a white, reflective fugitive dye.
2) Moisture loss during a 72-hour period shall not exceed 9 pounds per cubic yard when tested in accordance with ASTM C156.

G. Surface-applied sealing system:
   1. Manufacturers: One of the following, or equal:
      a. Euclid Chemical Co., Vandex Super.
      b. Kryton International, Inc., Krystol T1.
      c. Xypex Chemical Corp., Xypex Concentrate.
   2. Where surface-applied sealing system is placed over concrete containing permeability reducing admixture for concrete exposed to hydrostatic conditions (PRAH), provide products of same manufacturer providing the admixture.

## 2.05 EQUIPMENT

A. General:
   1. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material into mixers.

B. Batching equipment, or batch plant.
   1. Capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.

C. Mixing equipment:
   1. Mixers may be of stationary plant, paver, or truck mixer type, as appropriate to the Work.
   2. Capable of combining aggregates, water, and cementitious materials, and admixtures within specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.
      a. Maintain concrete mixing equipment in good working order, and operate at loads, speeds, and timing recommended by manufacturer or as specified.
      b. Proportion cementitious materials and aggregate by weight.
   3. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
   4. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
   5. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
   6. Retempering of concrete will not be permitted.
   7. Discharge entire batch before recharging.
   8. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
   9. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
   10. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
      a. Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
   11. Transit-mixed concrete:
      a. Mix and deliver in accordance with ASTM C94.

b. Total elapsed time between addition of water at batch plant and discharging completed mix.
c. Not to exceed 90 minutes.
d. Elapsed time at project site shall not exceed 30 minutes.
e. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
f. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.

12. Continuously revolve drum after it is once started until it has completely discharged its batch:
    a. Do not add water until drum has started revolving.
    b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

D. Other types of mixers: For other types of mixers, mixing shall be as follows:
1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

## 2.06 CONCRETE MIXES

A. General:
1. Develop and provide mix design for each Concrete Class listed in Table 3 of this Section.
2. Select and proportion mixes and document properties using 1 of the 2 methods that follow. Procedures and requirements for use of each alternative are specified in subsequent paragraphs of this Section.
    a. Field experience method.
    b. Trial batch method.
3. Organize and submit mix designs with data on all constituent materials and products for that mix for Engineer's review.
4. Do not place concrete until the mix design for that Concrete Class has been accepted by Engineer.
5. After acceptance, do not modify accepted mixes or provide new mixes without Engineer's prior review and acceptance of the proposed alternative.
    a. Exception: At all times, adjust batching of water to compensate for free moisture content of the fine aggregate used.
    b. For any change to approved mixes, Engineer may require new trial batching and testing program as specified in this Section before acceptance and use.
    c. For any change to approved mixes, make modifications within limits set forth in this Section.
    d. If there is change in source or quality of any constituent of the concrete class or mix, the revised mix will be considered a new class of concrete

and shall require full re-submittal of all data describing mix constituents, design, and testing.

6. Material sampling, mix designs, trial batch preparation and testing, modifications to mix designs, and any re-testing required to satisfy the requirements of this Section or to obtain satisfactory performance shall be at Contractor's expense and shall not be considered cause for delay.

B. Measurements of materials:
   1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
   2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
   4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
   5. Weighing cementitious materials:
      a. Weigh cementitious materials separately.
      b. Cement in unbroken standard packages (sacks): Need not be weighed.
      c. Weigh bulk cementitious materials and fractional packages.
   6. Measure mixing water by volume or by weight.

C. Requirements for mix proportioning:
   1. Develop and provide mixes that:
      a. 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 surface.
      b. Prevent unnecessary or haphazard changes in the consistency of the concrete supplied.
   2. Constituent materials:
      a. Provide concrete mixes composed of Portland cement or blended cement, blended aggregates, admixtures and water.
         1) Admixtures required for each concrete class are indicated in Table 3 of this Section. Admixtures not specifically required by that table for a specific Concrete Class are optional and may be included at the discretion of the Contractor based on Contractor's planned means and methods of construction.
      b. In no case shall returned fresh concrete or its constituents be incorporated into concrete batched for the Work.
   3. Minimum specified compressive strength:
      a. Minimum specified compressive strength is designated at 28 days, unless otherwise indicated in Table 3 of this Section.
      b. For locations where the placed concrete is adequately protected and is not subjected to loads for an extended period during construction, the Contractor may request that the period for achieving the minimum specified compressive strength be extended to 56 days. If accepted by the Engineer, provide mixes that achieve at least 75 percent of their minimum specified compressive strength after 28 days.

4. Proportions and consistency:
    a. Ratio of water to cementitious materials, and cementitious materials content:
        1) Conform to maximum and minimum cementitious material content requirements specified in Table 3 of this Section.
        2) Cementitious materials content: Consisting of Portland cement or blended cement as indicated in Table 3 of this Section, plus supplemental cementitious materials if aggregate testing indicates potentially reactive aggregates:
            a) Fly ash content:
                (1) Minimum: 15 percent of the total weight of cementitious materials.
                (2) Maximum: 25 percent of the total weight of cementitious materials.
    b. Aggregate size and content:
        1) Blend aggregates to produce an optimized gradation that combines well-graded coarse, intermediate, and fine aggregates in proportions that maximize the aggregate content of the mix, and that minimize the cement paste content of the mix.
            a) Percentage of individual fractions of the combined aggregate gradation retained on individual sieve sizes: Within the range shown in Attachment C - Combined Aggregate Gradation Chart ("Tarantula Curve").
            b) Sum of the percentages of individual fractions retained on the No. 8, No. 16, and No. 30 sieves: Greater than 20 percent.
            c) Sum of the percentages of individual fractions retained on the No. 30, No. 50, No. 100, and No. 200 sieves: Within the range of 25 percent to 40 percent.
    c. Determine bulk density and void content of the combined gradation of aggregates in accordance with ASTM C29. Results for combined aggregates shall not be the summation of results of testing of the individual gradations.
        1) Sample the combined aggregate from a flowing aggregate stream or conveyor in accordance with ASTM D75. Take care to ensure that the sample is representative of the proportions of the combined aggregate of the proposed mix.
        2) Reduce sample of combined aggregate to test sample size in accordance with ASTM C702, Method A - mechanical splitter or Method B - quartering.
        3) Perform bulk density test of combined aggregate in accordance with ASTM C29, Procedure A - rodding.
        4) Determine void content of the combined aggregate in accordance with ASTM C29, Procedure A - rodding. Specific gravity of the combined aggregate shall be determined in accordance with ASTM C136.
    d. Paste content: Limited to the following:
        1) Class A mixes without air entrainment: Maximum 28 percent measured by volume.
        2) Class A mixes with air entrainment: Maximum 28 percent measured by volume plus the target air content.

3) Paste content shall be limited to 200 percent of the void content of the combined aggregate gradation determined by ASTM C29.

e. Total water content:
   1) Not exceeding the water to cementitious material ratio specified in Table 3 of this Section.
   2) Not exceeding 245 pounds of water per cubic yard of concrete for Class A mix.

f. Coarseness/workability (Shilstone Method):
   1) Proportion mixes to fall into the "Optimal" zone (Zone II) when plotted on the Coarseness Factor Chart ("Coarseness Factor" versus "Workability Factor") included as Attachment B - Coarseness Factor Chart to this Section. Provide plot for each Class A mix to be used in the Work.
   2) Coarseness factor (CF) for each mix shall be calculated as the percent of the combined aggregate gradation retained on the 3/8 inch sieve, divided by the percent of the combined aggregate gradation retained on the Number 8 sieve, multiplied by 100, or:

$$CF = \frac{(\%\ \text{retained on 3/8 in sieve})}{(\%\ \text{retained on No. 8 sieve})} \times 100$$

   3) Workability factor (WF) for each mix shall be the percent of the combined aggregate gradation retained on the Number 8 sieve, adjusted for cement content in the mix.
      a) Determine volume of total cementitious material in the mix.
      b) For each 94 pounds of cement content above 564 pounds per cubic yard, increase workability factor by 2.5 units.
      c) For each 94 pounds of cement below 564 pounds per cubic yard, decrease workability factor by 2.5 units.
      d) Proportion adjustment factor by linear interpolation for each fraction of 94 pounds above or below the 564 pound basis.
      e) Example:
         650 pounds per cubic yard = 564 pounds + 86 pounds.
         Adjustment = (86 lb / 94 lb) x 2.5 = + 2.28.

D. Concrete Classes for use in the Work:
   1. Provide concrete classes listed in Table 3 of this Section.
   2. Provide normal weight concrete, having minimum weight of 140 pounds per cubic foot, unless otherwise noted.
   3. Pumped concrete:
      a. Provide pumped concrete that complies with all requirements of this Section.
      b. Mixes placed by pumping shall be considered a sub-class of each concrete class listed in Table 3 of this Section. Prepare and submit a separate mix design for each mix to be placed by pumping.
   4. Class PM concrete: In addition to the requirements of Table 3 of this Section, conform to the following:
      a. Minimum 28 day flexural strength: 650 psi when tested in accordance with ASTM C293.
      b. Cementitious materials content: 75 percent Portland cement plus 25 percent Class F fly ash (by weight), blended cement conforming to or

75 percent Type IL blended cement plus 25 percent Class F fly ash (by weight).

c. Aggregate:
   1) Minimum 55 percent coarse aggregate conforming to ASTM C33 size number 357 or size number 467.
   2) Substitute ASTM C33 size number 57 or size number 67 if mechanical paving equipment is not used.

**Table 3: Concrete Classes**

| Concrete Class[1] | Minimum Specified Compressive Strength at 28 days, f'c [2] (pounds per square inch) | Ratio of water to cementitious materials[3] (minimum - maximum). | Cementitious Materials Content (pounds per cubic yard of concrete by weight)[4] | Cement Type | Maximum Chloride Content (percent by weight of cement) | Maximum Size of Coarse Aggregate (ASTM C33) | Air Entrainment (percent), (n/a: not applicable) | Admixtures required[4,5,6] | Slump Range (inches) |
|---|---|---|---|---|---|---|---|---|---|
| A | 4,500 | 0.40 to 0.42 | 535 to 575 | ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(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) | No limit | #57 | 6±1.5 | AEA WRA | 3 to 6 |
| CE | 3,000 | 0.62 max. | 423 min. | ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(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) | 0.15 | #57 | 6±1.5 | AEA WRA | 3 to 6 |

Notes:

(1) Sub classes within major concrete classes are designated as follows:
NA: Without air entrainment.

(2) At locations where concrete will not be subjected to load from other elements of the structure or from Contractor's placing and/or backfilling operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Engineer.

(3) W/C Ratio = Ratio of water to cementitious materials 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.

| Table 3: Concrete Classes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Concrete Class[1] | Minimum Specified Compressive Strength at 28 days, f'c [2] (pounds per square inch) | Ratio of water to cementitious materials[3] (minimum - maximum). | Cementitious Materials Content (pounds per cubic yard of concrete by weight)[4] | Cement Type | Maximum Chloride Content (percent by weight of cement) | Maximum Size of Coarse Aggregate (ASTM C33) | Air Entrainment (percent), (n/a: not applicable) | Admixtures required[4,5,6] | Slump Range (inches) |

(4) Cementitious material includes Portland cement plus supplemental cementitious materials.

(5) Admixtures are designated as follows:
AEA: Air entraining admixture.
HRWR: High-range water-reducing admixture.
PRAH: Permeability-reducing admixture for concrete exposed to hydrostatic conditions.
SFR: Synthetic fiber reinforcement.
SRA: Shrinkage-reducing admixture.
WRA: Water-reducing admixture.

(6) At Contractor's option, each concrete class may include a high-range water reducing admixture (HRWR). Designate such mixes as the "class" specified followed by "SP" (e.g., A-SP, PM-SP, etc.). Submit as separate mixes for review. Slump range after addition of HRWR: 4 to 6 inches.

E. Install Concrete Classes in accordance with the following requirements unless otherwise indicated on the Drawings.
   1. Class A concrete: Structural concrete.
      a. Use Class A concrete at all locations unless other Classes are specified or indicated on the Drawings.
   2. Class A-NA concrete: Structural concrete without air entrainment.
      a. Class A-NA concrete may be used in lieu of Class A at indoor slabs (not subject to freezing and thawing) where inclusion of an air-entraining admixture makes it difficult to achieve the specified concrete finish.
   3. Class C concrete: Miscellaneous concrete fill and encasement.
      a. Class C concrete may be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
   4. Class CE concrete: Use Class CE for electrical conduit encasements.
   5. Class PM concrete: Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.

F. Concrete mix design documented by field experience:
   1. Mix design:
      a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for materials to be used in the mix for Engineer's review.

2. Historical records for similar mix.
    a. Determinations of similarity of materials and proportions between historical and proposed mixes shall be by the Engineer, and that shall be final.
    b. Historical record - Materials:
        1) Submit with each mix design the following data for a previously-supplied concrete mix similar to that proposed for this Work.
        2) Records demonstrating that the previously supplied mix included similar materials and proportions as those of the proposed mix.
            a) Documentation that the same concrete supplier will provide both mixes.
            b) Documentation that the materials used was from the same suppliers and had essentially the same properties, demonstrated by test data, as those proposed.
            c) Documentation that proportions of materials in the record mix are essentially the same as those proposed and that the specified compressive strength of the record mix is within 1,000 pounds per square inch of that required by this Section.
            d) Concrete supplier's statement describing any changes made to production of the record mix during the time period reported.
            e) Concrete supplier's statement that preparation and quality control procedures for the record mix were essentially the same as those to be employed for this Work.
    c. Historical record - Testing:
        1) Submit with each record mix, corresponding test data for slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
        2) Only records satisfying the following requirements will be accepted.
            a) All tests were conducted within a period of 1 year preceding the date of the Submittal.
            b) All tests were conducted over a period including not less than 45 days.
            c) Record of compressive strength testing includes at least 30 tests for slump and 28-day compressive strength.
            d) Record of compressive strength tests is consecutive. In other words, it includes all tests conducted on the subject mix within the 1-year time period described above (not just selected tests during that period).
            e) Submit concrete supplier's sworn statement confirming that all tests for the record mix have been reported.
            f) Tests for drying shrinkage are described in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".
            g) Provide supplementary testing if requested by Engineer.
    d. For mixes determined to be similar and to have an acceptable test history, acceptance criteria shall be as follows:
        1) Acceptance criteria:
            a) Slump: All tests within limits specified for record mix.
            b) Compressive strength: Average compression strength for tests, as determined by ACI CODE-350 not less than minimum required average strength.

c) Drying shrinkage: Within limits stated in subsequent paragraphs of this Section for “concrete mix design documented by trial batch preparation and testing”.

G. Concrete mix design documented by trial batch preparation and testing:
   1. Mix design and trial batches:
      a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for each combination of materials and proportions to be used for Engineer’s review.
         1) Determine water content of the mix based on curves showing the relation between water-cementitious materials ratio and the 7- and 28-day compressive strength of the concrete.
         2) Determine each curve using 4 or more points, each representing the average compressive strength value of at least 3 specimens tested at each age.
      b. After materials and proposed mix designs have been accepted by Engineer, have trial batches for each concrete mix design prepared by Contractor's testing laboratory.
         1) Prepare trial batches using the cementitious materials, aggregates, and admixtures proposed to be used for the Work.
         2) Provide batches of sufficient quantity to determine slump, workability, consistency, and finishing characteristics, and to provide sufficient specimens for testing.
      c. For each trial batch, make and test specimens to determine and report slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
         1) If trial batches do not produce concrete conforming to the specified requirements for slump, strength, workability, consistency, drying shrinkage, restrained shrinkage, and finishing, change mix proportions and, if necessary, sources of materials.
         2) Make additional trial batches and perform additional tests until a batch that conforms to requirements of this Section is produced.
   2. Testing - Slump:
      a. Determine slump in accordance with ASTM C143.
      b. Acceptance criterion: Slump within range specified.
   3. Testing - Compressive strength:
      a. Prepare 4 inch diameter by 8 inch long cylinders in accordance with ASTM C31 for tests specified in this Section.
      b. Determine average compressive strength:
         1) Test at least 12 cylinders from each trial batch for compressive strength in accordance with ASTM C39.
         2) Test 4 cylinders at 7 days, another 4 at 28 days, and another 4 at 56 days.
         3) Calculate average compression strength for 7 day tests, for 28 day tests, and for 56 day tests.
         4) Calculate ratios for:
            a) Average 7 day strength to average 28 day strength.
            b) Average 28 day strength to average 56 day strength.

c. Determine the required average compressive strength for each mix, f'cr, as described in the following paragraphs:
    1) Calculate required average compressive strength (f'cr) based on the minimum specified 28-day compressive strength, f'c, plus a standard deviation determined from the test history available for that mix.
    2) Determine f'cr as specified in ACI CODE-350, except as modified in the following paragraphs:
        a) Where 15 or more 28-day compressive strength tests are available, calculate standard deviation as described in the preceding paragraphs for "concrete mix design documented by field experience". Add this standard deviation to the specified minimum compressive strength to determine the required average compressive strength (f'cr) for the mix.
        b) Where fewer than 15 compressive strength tests at 28 days are available, determine minimum required compressive strength, (f'cr) from Table 4 of this Section.

**Table 4: Required Average Compressive Strength, Fewer than 15 Tests Available**

| Minimum 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 |
| Over 5,000 | f'c + 1,400 |

d. Acceptance criterion: Average compressive strength of the 4 cylinders tested at 28 days, or of the 4 cylinders tested at 56 days when permitted by the Engineer, shall equal or exceed the required average compression strength, f'cr for that concrete mix design.

4. Testing - Chloride content:
    a. 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 3 of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days.
5. Testing - Drying shrinkage - Prism specimens:
    a. Class A (including A, A-NA, A-SP, and A-NA-SP), and Class PM: From trial batch for each mix, prepare 10 drying shrinkage specimens in accordance with ASTM C157 Divide specimens into 2 groups of 5 specimens each: 1 group including shrinkage-reducing admixture, and 1 group without shrinkage-reducing admixture.
    b. Prepare, cure, and test both groups in accordance with ASTM C157, except as modified in the following paragraphs.
        1) Remove drying shrinkage specimens from molds at age of 23 hours, plus or minus 1 hour, after trial batching.
            a) Immediately place them in lime-saturated water maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, for at least 30 minutes.
            b) Remove specimens from the water and wipe with a damp cloth.
            c) Measure to nearest 0.0001 inch to determine original length.

d) Record measurements and re-submerge specimens in lime-saturated water at 73 degrees Fahrenheit, plus or minus 3 degrees, for moist curing.

2) Maintain submerged curing conditions at 73 degrees Fahrenheit, plus or minus 3 degrees, for 7 days. 7 days after batching, remove specimens from water and repeat measuring procedures.

3) Immediately store specimens in a humidity controlled room maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, and at 50 percent relative humidity plus or minus 4 percent for remainder of the test.

4) At periods of 14, 21, 28, and 56 days after batching, remove specimens from curing room and repeat measurements.

c. Drying shrinkage test report:

1) Report measurements of all specimens at 1, 7, 14, 21, 28, and 56 days after batching.

2) Using measured length at 7 days as base length for drying shrinkage, calculate the following for each measuring period:

a) Drying shrinkage of each specimen. Determine as difference between the 7-day base length and measured length for each period.

b) Average of these differences. If drying shrinkage of any specimen departs from the average of the measurements for each period by more than 0.0004 inch, disregard results obtained from that specimen.

c) Percentage of drying shrinkage from batching to date of measurement.

d. Drying shrinkage acceptance criteria:

1) Average shrinkage of trial batch concrete specimen group at 28 days after batching, when measured and cured as indicated, shall not exceed 0.035 percent.

e. Mixes accepted by Engineer:

1) Retain drying shrinkage test specimens. Bag in re-sealable plastic bags and submit to Engineer.

2) Indicate trial batch identifier, specimen number, and date of final measurements on each specimen bag.

## 2.07 SOURCE QUALITY CONTROL

A. Sample and test materials in accordance with the following requirements:

1. Sampling, testing, and reporting frequency:
   a. In preparation for mix design submittals and trial batch tests.
   b. Whenever there is a change in source of the material, or a significant change in the characteristics or quality of materials from the same source.
   c. For each 10,000 cubic yards of concrete mix produced.
   d. At intervals not exceeding 90 calendar days, unless otherwise specified in the following paragraphs.
2. Supplemental cementitious materials.
   a. Sample and test fly ash in accordance with ASTM C311.
3. Aggregate:
   a. Sample combined aggregate in accordance with ASTM D75 and D3665, and test for gradation in accordance with ASTM C136.

b. At least once every 30 days, and when requested by the Engineer.
c. Submit test results.

4. Cementitious materials:
   a. Sample and test cementitious materials and provide mill certificates demonstrating compliance with ASTM C150 or ASTM C595, and additional requirements of this Section.
      1) Determine alkali content by method set forth in ASTM C114.
   b. At least once every 90 days, and when requested by the Engineer.
   c. Submit test results.

B. Batch materials in accordance with the following requirements:
   1. Concrete batch weights: Control and adjust so as to secure maximum yield, and at all times maintain proportions of concrete mix within specified limits.
   2. Aggregates:
      a. Obtain aggregate from a source capable of providing uniform quality, moisture content, and grading during any single day's operation.
      b. Furnish satisfactory means at batching plant for checking moisture content of fine aggregate for each batch.
   3. Admixtures:
      a. Batch solutions using mechanical batcher capable of accurate measurement.
      b. Air entraining admixture: Add to batch in portion of the mixing water, unless otherwise recommended by the admixture manufacturer.

## PART 3 EXECUTION

### 3.01 PREPARATION

A. Prepare and submit mix designs for each Concrete Class indicated in Table 3 of this Section.

B. Submit proposed sequence of concrete placements. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested by the Contractor and accepted by the Engineer.
   1. Use construction methods and sequence work to allow concrete placement to reach adequate strength and to be constructed with required support to prevent overstress of the concrete structure during construction.

C. Make provisions for monitoring weather conditions:
   1. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.
   2. Monitor the weather forecast beginning at least 48 hours prior to any concrete placement and make provisions for cold weather concreting or hot weather concreting if those conditions exist or are forecast to exist during the period of placement, finishing, and curing.
      a. Record temperature, relative humidity, and wind speeds for each placement beginning at least 24 hours before scheduled delivery of concrete.

D. Place no concrete without Engineer's prior acceptance of conditions.

E. Notify the Engineer in writing that preparations are complete and ready for placement of concrete. Such notification shall indicate readiness - not just intention - to place concrete for the designated portion of the Work.
   1. Submit notification to Engineer on forms provided by or acceptable to the Engineer and bearing the signature of Contractor's superintendent.
      a. Sample form is included at the end of this Section, see Attachment B - Coarseness Factor Chart.
   2. Submittal of notification will be Contractor's certification that preparations are complete and in accordance with the Contract Drawings and Specifications.
   3. Provide notification for Engineer to make final observations at the locations of concrete placements not less than 24 hours before commencing placement of concrete.

## 3.02 CONCRETE JOINTS

A. Locations of joints are indicated on the Drawings.
   1. In order to preserve strength and watertightness of structures, make no other joints, except as authorized by the Engineer.
   2. Construct joints where indicated, and as indicated on the Drawings.
   3. Where joint locations are not indicated on the Drawings, submit Contractor's proposed locations for Engineer's review and acceptance. Provide construction joints in slabs and walls at intervals not greater than 35 feet.

B. Time between placements of adjacent concrete separated by joints.
   1. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
      a. Slabs.
      b. Walls.
   2. Provide not less than 7 days (168 hours) between placement of the lower and upper pours for the following:
      a. Walls over slabs.
      b. Slabs over walls.
      c. Slabs keyed into the sides of walls.
   3. For the following structures, provide not less than 14 days between placements of concrete in adjacent concrete wall placements. Place concrete for slabs in accordance with ACI PRC-302.1, Figure 10.1.1.1b with not less than 14 days between placements of strips cast first and infill strips.
      a. Advanced Treatment Building.
      b. Operations Building.
      c. Equilization Basin.
      d. Bioreactor 3.
      e. Secondary Clarifier.

C. Edges of joints:
   1. Provide joints have edges detailed as indicated on the Drawings.
   2. Protect wall and slab surfaces at edges from concrete splatter. Thoroughly clean adjacent surfaces after completion of each placement.

D. Joint construction:
    1. Preparation of forms:
        a. Provide cleanout holes at base of each wall and column for inspection and cleaning.
        b. Wash forms and adjacent joint surfaces of sawdust, chips, and other debris after forms are built, and immediately before concrete or grout placement.
        c. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use a vacuum cleaner for their removal, and then flush cleaned surfaces with water.
    2. Before placing concrete against previously placed concrete, thoroughly clean the prior placement of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of pressure washing.
    3. Provide and install waterstops, expansion joint material, and other similar materials as indicated on the Drawings and as specified.
        a. Take special care to ensure that waterstops are secured in proper position.
        b. Take special care to ensure that concrete is well consolidated around and against waterstops during placement.
    4. Horizontal joints:
        a. As initial placement over cold joints, thoroughly spread bed of cement grout as specified in Section 03600 - Grouting.
            1) Thickness: Not less than 1/2 inch or more than 1 inch.
        b. For wall placements above planned cold joints, placement of cement grout will not be required for locations where the wall mix includes high-range water-reducing admixture (“superplasticizers”), and the Contractor can demonstrate dense concrete joints without voids or honeycomb after the forms are removed.

## 3.03 MEASURING AND BATCHING MATERIALS

A. Measurements of materials:
    1. Proportion and measure cementitious materials and aggregates by weight.
        a. Weigh cementitious materials separately.
        b. If bulk cementitious materials are used, weigh them on separate visible scale that will accurately register scale load at any stage of weighing operation from zero to full capacity.
        c. Cement in unbroken standard packages (sacks) need not be weighed.
    2. Mixing water: Measure by volume or by weight.
    3. Other mix constituents: Measure by weight, except as otherwise specified or accepted by the Engineer.
    4. Weighing and measuring devices:
        a. Use equipment designed and constructed specifically for that purpose.
        b. Furnish devices capable of weighing successive quantities of individual material measured to within 1 percent of desired weight of that material.
        c. Bearing valid seal of the department of weights and measures for the authority having jurisdiction over the Work.
    5. Measurements and measuring devices:
        a. Subject to review by the Engineer.

B. Batching:
    1. Admixtures shall be added at the concrete batch plant.

2. Addition of admixtures in the field is permitted only with prior acceptance by the Engineer, and only when the following conditions are satisfied:
    a. Dosage and mixing is personally overseen by concrete supplier's trained technologist.
    b. Adequate mixing is provided after addition.
    c. Maximum time to placement of concrete remains 90 minutes after water added to mix - not 90 minutes after any field additions/adjustments.
    d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

## 3.04 MIXING AND TRANSPORTING

A. Machine mixing:
    1. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer and ready for complete mixing with all mixing water.
    2. Procedure of mixing cementitious materials with sand, or with sand and coarse aggregate, for delivery to project site for final mixing and addition of mixing water is not permitted.
    3. Remixing of concrete that has started to take its initial set (“retempering”) is not permitted.
    4. Discharge entire batch before recharging.
    5. Volume of mixed material per batch: Not exceeding manufacturer's rated capacity of mixer.

B. Transit-mixed concrete:
    1. Mix and deliver in accordance with ASTM C94, except as modified in this Section.
    2. Total elapsed time between addition of water at batch plant and discharging completed mix:
        a. Not to exceed 90 minutes or 300 revolutions of the mixing drum.
        b. Under conditions contributing to rapid setting, total elapsed time permitted may be reduced by the Engineer.
    3. Temperature - minimum and maximum allowable during mixing and transporting:
        a. Minimum: 50 degrees Fahrenheit.
        b. Maximum: 90 degrees Fahrenheit.
    4. Continuously revolve drum after it is started until it has completely discharged its batch.
        a. Do not add water until drum has started revolving.
        b. Engineer reserves the right to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

C. Concrete delivery:
    1. Furnish to the Engineer a delivery ticket for each batch of ready mixed concrete within 24 hours after delivery. Include the following information on each ticket:
        a. Time of day concrete was batched, and time of day that discharge from the truck is complete.

b. Printed record of the individual weight of each of the following constituents in the batch: Fine aggregate, coarse aggregate, cement, pozzolan, and water.
c. Concrete Class as defined in Table 3 of this Section.
d. Type, brand, and quantity of each admixture in the batch.
e. Total volume of water allowed in the mix, volume of mixing water added at the batch plant, volume of mixing water withheld from the mix during batching, and total volume of any water added to the mix after leaving the batch plant.
    1) In no case shall volume of mixing water withheld result in a water/cementitious materials ratio less than the minimum values specified in Table 3 of this Section.
f. Number of revolutions of transit truck at arrival on site, and total number of revolutions when discharge is complete.
g. Volume of concrete delivered in the batch.
h. Numerical sequence of the batch delivered for that placement.

2. Additional water may only be added to the mix when the following conditions are fully satisfied:
    a. Batch ticket showing total volume of water already added and maximum volume of water that may be added is available for Engineer's observation before any additional water is added.
    b. Total volume of water in the mix after the addition will be less than the maximum allowable volume of water indicated on the ticket.
    c. Full concrete load is still within the truck's mixing drum, and truck has not begun to discharge the load. Under no conditions shall water be added in the field to a partial truckload of concrete.
    d. Volume of water added, and time of addition are clearly marked for record on the batch ticket delivered to the Engineer.
3. Addition of admixtures in the field is permitted only with prior approval by the Engineer, and when the following conditions are satisfied:
    a. Dosage and mixing is personally overseen by concrete supplier's trained technologist and admixtures supplier's representative.
    b. Adequate mixing time is provided after addition of admixtures.
    c. Maximum time to placement of concrete remains 90 minutes after water is added to the mix - not 90 minutes after any field additions/adjustments.
    d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

D. Conveying concrete:
1. Convey concrete from mixer to location of final deposit by methods that prevent separation or loss of materials.
2. Use equipment for chutes, pumps, and conveying of concrete of such size and design as to ensure practically continuous flow of concrete, from delivery to the point of placement, without separation of materials.
3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

## 3.05 PLACING AND CONSOLIDATING

A. Preparation:
   1. Obtain Engineer's acceptance of completed preparations before placing concrete.
      a. Notify Engineer in writing that all preparations are complete and ready for placement of concrete. Such indication shall indicate readiness, not just intention, to place concrete for the designated portion of the Work.
      b. Submit completed Attachment D - Contractor's Concrete Placement Checklist Form.
   2. Confirm completeness of the following before notification of readiness is given to Engineer:
      a. Place forms, reinforcement, screeds, anchors, ties, and inserts in final position.
      b. Reinforcement is secure and properly fastened in its correct position.
      c. Loose form ties at construction joints have been retightened.
      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 have been cleaned of debris and form release agents are applied as specified.
   3. Preparation for placement of footings and slabs on grade:
      a. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
      b. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
      c. If subgrade surface becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
      d. Do not place concrete if subgrade is muddy or soft.
   4. Keep sufficient protective coverings on hand at all times for protection of concrete during and after placement.
      a. Protect concrete placed before rain to prevent water from coming in contact with such concrete.
      b. Protect concrete placed before winds to prevent excessive drying or embedment of debris in the finished surfaces.

B. Concrete placement:
   1. Do not place concrete:
      a. With slump outside the limits specified in Table 3 of this Section.
      b. In which initial set has occurred, or that has been retempered.
      c. During rainstorms or high velocity winds.
   2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
      a. Do not deposit concrete in large quantities in one place, and then work material along forms with vibrator or by other methods.
   3. Do not drop concrete freely into place from height greater than 5 feet. Use tremies for placing concrete where drop is over 5 feet.
   4. Place concrete on slopes starting from bottom of slope and working upward.
   5. Place concrete in horizontal lifts not exceeding 24 inches in depth and bring up evenly in all parts of forms.

6. After concrete placement begins, continue in a continuous operation without significant interruption until the end of the placement. Plan and implement precautions to prevent any delay, between layers or adjacent volumes, from exceeding 20 minutes.
7. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout over surface before placing additional concrete. Provide grout layer thickness of not less than 1/2 inch or more than 1 inch.
8. Placement of concrete for slabs, beams, or walkways:
    a. If cast monolithically over walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
    b. Allow set time of not less than 1 hour for shrinkage.
        1) During waiting time, keep top surface of concrete moist, but not wet.
        2) Do not permit water to pond or stand on the surface.
        3) Do not coat surface with evaporation retarders or curing agents.
    c. Start placement above wall or column with layer of cement grout as described in the preceding paragraph.

C. Consolidating concrete:
1. Consolidate concrete with aid of acceptable mechanical vibrators.
2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the Work.
3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
4. Vibrators:
    a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
    b. In addition to vibrators in actual use while concrete is being placed, have on hand a minimum of 1 spare vibrator in operable condition.
    c. Do not place concrete until it has been confirmed that all vibrating equipment, including spares, are in operable condition.
5. Place concrete solidly against forms and concrete surfaces, leaving no voids or honeycomb.
6. Make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
7. Do not over-vibrate so as to produce segregation.

## 3.06 FINISHING CONCRETE

A. Provide concrete finishes in accordance with Section 03366 - Concrete Finishes, unless otherwise indicated on the Drawings.

B. Liquid evaporation retardant:
1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, coat the surface of the concrete with a liquid evaporation retardant immediately after screeding.
2. Conditions that result in rapid evaporation of moisture are defined as any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.1 pounds per square foot per hour as determined by the Menzel Formula

and nomograph published in ACI PRC-305 and included as Attachment A - Menzel Formula and Nomograph to this Section.

3. Apply evaporation retardant again after each finishing operation as necessary to prevent drying shrinkage cracks.
4. Do not work evaporation retardant into the surface of the concrete.
5. Do not use evaporation retardant as finishing aid (to rehydrate surface a creamy state for finishing).

C. Concrete sealer:
1. Floors and slabs to receive concrete sealer: See Room Finish Schedule on the Drawings, and Section 03366 - Concrete Finishes.

## 3.07 CURING

A. Cure concrete by methods specified in this Section.

B. Keep concrete continuously moist and at an average daily temperature of at least 50 degrees Fahrenheit for a minimum of 7 days after placement.
1. Provide at least 350 degree days of curing (350 degrees times 7 days of 24 hours each).
2. If hourly temperatures at any surface of a concrete placement drop below 50 degrees Fahrenheit during the curing period, count the period below 50 degrees Fahrenheit as zero degrees, and extend the curing time to compensate.

C. Schedule of curing methods:
1. Cure the following concrete surfaces using water curing, or plastic membrane curing.
a. Floor surfaces of water containment structures.
b. Surfaces where additional concrete will be placed over or against the surface, including concrete joints.
c. Surfaces where grout or other toppings will be placed over the surface.
d. Slabs scheduled to receive concrete sealer, or other bonded or adhered architectural finishes.
e. Formed surfaces scheduled to receive coatings, paint, adhered masonry, cementitious materials, or other similar finishes, and where formwork is removed within 7 days after concrete placement.
f. Horizontal concrete surfaces at tops of walls.
2. Cure the following concrete surfaces by water curing, plastic membrane curing, or sprayed curing membrane. Selection of methods shall be at the Contractor's option.
a. Surfaces not listed in the preceding paragraph.

D. Water curing:
1. Keep surfaces of concrete constantly and visibly wet, day and night, for period of not less than 7 days.
a. Each day forms remain in place will be counted as 1 day of water curing.
b. Do not loosen form ties during period when concrete is cured by leaving forms in place. No further curing credit will be allowed for forms remaining in place after contact has been broken between concrete surface and forms.

2. Begin water curing as soon as concrete attains initial set.
3. Maintain a wet surface by ponding, continuous sprinkling, covering with saturated burlap, or otherwise saturating the surface by means acceptable to Engineer.
    a. Flood top of walls with water at least 3 times per day and keep surfaces moist at all times during the 7-day curing period.
    b. Provide plastic sheet material over surfaces if required to maintain a wet surface during arid or windy conditions. See plastic membrane curing requirements for additional details.
4. Use water having a temperature within 20 degrees Fahrenheit of the temperature of concrete, and not lower than the minimum temperature allowed for the concrete surface during curing.

E. Plastic membrane curing:
1. Install plastic membrane as soon as concrete is finished and can support limited pedestrian traffic without damage.
2. Cover entire surface of finished concrete with membrane.
3. Anchor membrane to prevent uplift from wind or air trapped below the sheet.
4. Fully seal joints and edges to provide full seal around perimeter.
5. Keep concrete under plastic membrane moist, regularly monitoring surfaces and adding supplemental moisture if necessary. Add water as specified for water curing.

F. Sprayed membrane 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 after removal of forms, do not use membrane curing compound. Instead, provide water curing for not less than 7 days.
    b. Do not remove sprayed membrane curing compound from concrete in less than 7 days after initial application.
    c. When application of curing compound at concrete joints is accepted by Engineer, take care to apply curing compound to all surfaces along full profile of joints.
2. Apply curing compound by mechanical, power operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
    a. Apply curing compound in at least 2 coats.
    b. Apply each coat in direction turned 90 degrees from application direction of the preceding coat.
    c. Apply curing compound in sufficient quantity so that concrete has uniform appearance and its natural color is effectively and completely concealed immediately after spraying.
    d. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
3. Thickness and coverage of curing compound:
    a. Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
    b. Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and is more than is customary in the trade. Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice.

4. If Contractor desires to use a curing compound other than specified product, coat sample areas of concrete wall with proposed curing compound, and also coat similar adjacent area with the specified compound in the manner specified, for comparison:
    a. If proposed sample is not equal or better, in opinion of the Engineer, the proposed substitution will not be allowed.
5. Removal of curing compound.
    a. After curing period is complete, remove curing compound placed on surfaces that will receive additional concrete, including all concrete joint surfaces, by heavy sandblasting or by other means acceptable to Engineer. Complete removal and cleanup prior to placing any new concrete against the surface.
    b. Where additional finishes will be applied over concrete surfaces, unless otherwise recommended by the manufacturer of the finish to be applied, remove curing compound by sandblasting. Provide blasting as necessary to fully remove curing compound.
6. Prior to final acceptance of the Work, remove, by sandblasting or by other method acceptable to the Engineer, any curing compound on surfaces exposed to process water or exposed to view, so that only natural color of finished concrete is visible and uniform over the entire surface.

## 3.08 PROTECTION

A. General:
    1. Keep forms in place, as specified in Section 03102 - Concrete Formwork, to provide curing and to protect concrete surfaces and edges from damage.
    2. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Loading of concrete members:
    1. Placement of loads on or against green concrete is not permitted.
    2. Do not place soil against walls, or fill over the top of concrete until conditions designated in the following paragraphs are satisfied:
        a. Walls have been cast to their full height in the structure and have achieved their minimum specified 28-day compressive strength.
        b. Connecting slabs and beams that brace the walls are in place, are complete, and (in the case of concrete) have achieved their minimum specified 28-day compressive strength.

## 3.09 COLD WEATHER CONCRETING

A. Implement cold weather concreting procedures during periods of cold weather as defined in this Section.
    1. Comply with the recommendations of ACI PRC-306 and this Section.

B. Prepare a cold weather concreting plan. Maintain at least 1 copy of the plan on site. Provide plan for review if requested by the Engineer.
    1. Include procedures for batching, delivery, placement, curing, protection, and for monitoring and recording the temperature of the concrete and the surrounding environment.

2. Describe procedure to be implemented in the event of abrupt changes in weather conditions or of equipment failure.
3. Review cold weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by Engineer before beginning concrete placements.

C. Preparation:
1. Do not place concrete over frozen subgrade materials. Provide insulating material and supplementary heat if required to maintain a thawed surface.
2. Do not place concrete around metallic elements whose temperature is less than 40 degrees Fahrenheit. If heating is required, use processes that do not alter the metallurgical properties of the elements.
3. Remove snow, ice, and frost from reinforcement, embedments and forms. Schedule such removal immediately before concrete placement so that surfaces do not refreeze.

D. Batching, delivery, placement and finishing:
1. Accelerating admixtures will not be permitted.
2. Based on temperature of the environment and the surfaces where concrete will be placed, select and maintain mix temperature as recommended in ACI PRC-306.
   a. Make provisions for temperature loss during delivery and placing.
   b. Place concrete at or slightly above the minimum recommended batch temperatures. Do not exceed these minimum values by more than 20 degrees Fahrenheit.
3. Heating: If temperature of water or aggregates is below 35 degrees Fahrenheit, heat the materials.
   a. Mixing water: Do not heat above 140 degrees Fahrenheit.
   b. Aggregates:
      1) Heat uniformly to eliminate ice, snow, and frozen lumps of material.
      2) Avoid overheating.
      3) Do not exceed average temperature of 140 degrees Fahrenheit or spot temperature of 200 degrees Fahrenheit.

E. Protection and curing:
1. Protect concrete to provide continuous warm moist curing immediately after placement and during protection period.
2. Minimum protection period: 7 days.
3. During and immediately after the protection period, maintain temperature in accordance with Table 5 of this Section. Provide record of temperature during placement and curing as specified in the following paragraphs.
   a. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete.

Table 5: Concrete Temperatures - Normal Weight Concrete

| Section Thickness (inches) | <12 | 12 to <36 | 36 to <72 |
|---|---|---|---|
| During Protection Period:<br>As maintained (minimum) | 55°F | 50°F | 45°F |
| After Protection Period:<br>Gradual drop during first 24 hours (maximum) | 50°F | 40°F | 35°F |

4. Provide plastic sheeting, polystyrene foam sheets, insulating blankets, and supplemental heating if required to maintain moisture and the specified temperatures during protection.
    a. Protect insulating blankets from moisture in the concrete and from rain or snow using impermeable sheeting.
    b. Supplemental heating units:
        1) Vent units to outside atmosphere. Do not exhaust heater flue gasses into the enclosed and protected area.
        2) Make provisions to heat the flow freely within protected area, and to maintain a uniform temperature throughout the space.
        3) Locate units to avoid local drying or uneven heating of concrete surfaces.
    c. Pay particular attention to maintaining required temperature and moisture at edges and corners.
5. At the end of the protection period, allow concrete to cool gradually to the ambient temperature.
    a. Maximum temperature drop over the first 24-hour period shall be as specified above.
    b. Where temperature of concrete exceeds ambient by 20 degrees Fahrenheit or more, loosen forms and leave in place for at least 24 hours before removal.
    c. If water curing has been used, maintain concrete temperature as specified in the following paragraphs for at least 24 hours after water curing is terminated. Allow water-cured concrete to air dry for at least 3 days before exposure to freezing temperatures.

F. Temperature records:
1. For each area of concrete placed or cured during cold weather, record the temperature of concrete and the ambient environment.
    a. Maintain temperature records on site and make records available for review by the Engineer upon request.
    b. Deliver a final copy of each record to Engineer for project files not more than 14 calendar days after the date concrete was placed.
2. Concrete delivered for placement.
    a. Measure and record temperature at the point of discharge in accordance with ASTM C1064.
    b. Note temperature on the batch ticket.
3. Concrete during the protection period:
    a. Furnish and locate self-recording thermometers (maximum/minimum) around each placement. Number and location of thermometers shall be sufficient to represent temperatures around the entire concrete placement.
    b. Position thermometers to record the temperature at each edge or corner and at the middle of the placement area.
4. Include in the temperature record of each placement the following information, recorded legibly on a single sheet.
5. In the event that evaluations of the efficacy of concrete protection and curing are required, the lowest temperature recorded in any placement during each 24-hour period will be assumed to be the temperature at which the entire placement was maintained. Protection periods with any temperature records will be assumed to have provided no protection or curing, and the protection period will be extended by 2 days for each day without protection.

## 3.10 HOT WEATHER CONCRETING

A. Implement hot weather concrete procedures during periods of hot weather as defined in this Section.
   1. Comply with the recommendations of ACI PRC-305 and this Section.

B. If placements during hot weather are expected, and when requested by the Engineer, prepare a hot weather concreting plan.
   1. Maintain at least 1 copy on site.
   2. Provide plan for review if requested by the Engineer.
      a. Include procedures for batching, delivery, placement, curing, protection, and monitoring and recording the temperature of the concrete and the surrounding environment.
      b. Describe procedures to be implemented in the event of abrupt changes in weather conditions, or in the event of equipment failure.
      c. Review hot weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by Engineer before beginning concrete placements.

C. Preparation:
   1. Do not place concrete against forms, reinforcement, or embedments with a surface temperature greater than 120 degrees Fahrenheit.
      a. If necessary, to maintain maximum concrete temperature during placing, cool forms and reinforcement to temperature below 90 degrees Fahrenheit using water or shades.
      b. Do not allow water to puddle in forms or placement areas.
   2. Moisten forms or subgrade to maintain a saturated surface without standing water or soft spots.
   3. Provide windbreaks, shades, fog spray, sprinkling, wet cover, or other means required to protect concrete from premature loss of moisture and rapid temperature gain.

D. Batching and delivery:
   1. Retarding admixtures will not be permitted.
   2. Temperature of concrete delivered for placement shall not exceed 90 degrees Fahrenheit.
      a. Maintain uniform temperature in the mix below this level during batching, delivery, placing, and consolidation.
      b. Temperature of mix, even if below the maximum allowable temperature specified, shall be maintained at a level to avoid loss of slump, flash setting, or cold joints in placements.
   3. If necessary:
      a. Mix water may be chilled or replaced with ice to maintain mix temperature. Where mix water is replaced with ice, provide replacement at a 1-to-1 ratio by weight.
      b. Shade transit mixed concrete trucks, or cool mixing outside of container with water to control temperature of concrete.

E. Placing and finishing:
   1. Place and finish concrete promptly. Place so that vertical lift lines will not be visible in exposed concrete surfaces.

2. Provide plastic sheeting, fog nozzles, shades, or other means to reduce concrete temperature and protect from moisture loss.

F. Protection and curing:
   1. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete temperatures over full area and edges of concrete.
   2. Flatwork: Protect and cure using water curing methods as specified in this Section.
      a. Water curing:
         1) Keep concrete continuously wet and make provisions for runoff.
         2) For sprinkling or soaker hoses, maintain temperature of water as close as possible to the temperature of the concrete to minimize effects of thermal shock.
   3. Formed surfaces: Protect and cure using forms left in place or membrane curing methods as specified in this Section.
      a. Cover forms and keep continuously moist for at least 24 hours after placement.
      b. Loosen forms as soon as this can be accomplished without damaging the concrete.
      c. Maintain continuously moist surfaces by fogging or spraying with water, or by application of curing compound as specified.

## 3.11 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as required by Section 01450 - 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. See Section 01455 - Regulatory Quality Assurance - Special Tests and Inspections for requirements.
      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 4 firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold 10 specimens. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through shipment to Owner'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 requirements of ASTM C143. Test slump at the following intervals:
    1) 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 to see if mortar or moisture flows from slumped concrete.
        b) Reject concrete if mortar or moisture flows out of 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 beginning of each placement.
    2) As often as necessary to keep entrained air within specified range, but not less than every 6th truck.
    3) When requested to do so by the Engineer.
    4) Test air entrainment in concrete in accordance with ASTM C173. If air entraining admixtures used for the Work require alternate testing procedures, advise the independent testing laboratory well in advance of the dates of testing, and confirm that appropriate equipment and personnel are provided for the test.
    5) Make air test at point of delivery (discharge from mixer). For pumped concrete, make air tests at point of delivery and at point where expelled after pumping for placement.
f. Compressive strength in accordance with ASTM C39. Required number of cylinders is as follows:
    1) Not less than 6 cylinder specimens, 4 inches in diameter by 8 inches long, will be tested for each 150 cubic yards of each class of concrete, with minimum of 6 specimens for each class of concrete placed; not less than 6 specimens for each half day's placement; and not less than 2 sets of 6 specimens for each structure.
    2) 1 cylinder will be broken at 7 days, 1 at 14 days, and 3 at 28 days. 6th cylinder may be used to evaluate strength after 28 days if requested by the Engineer.
    3) Retain and store “6th cylinders” (tested and untested) at testing laboratory until 56 days. Break “6th cylinder” when directed by the Engineer.
g. Provide full access for Engineer to observe concrete sampling and testing at any time.

## 3.12 FIELD QUALITY CONTROL BY OWNER

A. Provide on-site inspection and field quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.

B. Special tests and inspections: See Section 01455 - Regulatory Quality Assurance.

C. 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.

D. 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 Contract Documents.
      a. If such additional testing shows that the material 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, Owner will pay the cost of these tests.

## 3.13 NON-CONFORMING WORK

A. Remove and replace or repair non-conforming and defective work.
   1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
   2. Provide replacement or repair of non-conforming work by means acceptable to the Engineer and at no additional cost to Owner.
   3. Project schedule will not be extended based on work to address non-conforming concrete.

B. Concrete not conforming to the specified requirements for properties of plastic concrete: Remove from the site and replace with conforming materials at no additional cost to Owner.
   1. Temperature: Do not use concrete having a temperature above or below the limits specified in this Section.
   2. Slump: Do not place concrete that does not conform to requirements for slump.
   3. Air entrainment: Do not use concrete that does not conform to requirements for percentage of entrained air.

C. Concrete not conforming to the specified requirements for compressive strength:
   1. Concrete is expected to reach a compressive strength equal to or greater than the minimum specified compressive strength f'c in Table 3 of this Section.
   2. Strength of concrete will be considered acceptable if following conditions are satisfied.
      a. Averages of all sets of 3 consecutive strength test results is greater than or equal to the specified compressive strength f'c.
      b. No individual strength test (average of 3 cylinders) falls below the strength specified in Table 6 of this Section.
      c. Where relationships between 7-day and 28-day compressive strength, or between 28-day and 56-day compressive strength, have been provided as part of the mix design submittals:
         1) 7-day strength may be considered as an indication of 28-day strength provided effects of temperature and humidity between 7 days and 28 days are taken into account.

2) 28-day strength may be considered as indication of 56-day strength provided effects of temperature and humidity between 28 days and 56 days are taken into account.

| Table 6: Strength Compliance Requirements | |
|---|---|
| **Minimum Specified Compressive Strength, f'c (pounds per square inch)** | **Lower Bound of an Individual Compressive Strength Test (pounds per square inch)** |
| Less than 5,000 | f'c - 500 |
| Over 5,000 | f'c - (0.10 x f'c) |

3. Non-compliant strength tests.
   a. Mark non-compliant strength test reports to highlight the non-complying results, and immediately forward copies to all parties on the test report distribution list.
   b. Initial treatment may consist of additional curing of affected portion(s) followed by not less than 3 cores at each affected area, taken in accordance with ASTM C42 and ACI CODE-318. Obtain Engineer's acceptance of proposed coring locations before proceeding with that work.
   c. Submit report of compressive strength testing for Engineer's review.
   d. If requested by the Engineer, provide additional cores, and obtain petrographic testing in accordance with ASTM C856. Submit results for Engineer's review.
   e. If additional curing does not bring the average strength of 3 cores taken in affected area to at least specified compressive strength f'c, designate such concrete in affected area will be considered defective.
   f. Engineer may require the Contractor to strengthen defective concrete by means of additional concrete, additional reinforcing steel, or replacement of defective concrete, all at the Contractor's expense.

D. Concrete sections or surfaces with honeycombing and voids:
   1. Provide repairs having surface appearance and finish consistent with that of the surrounding work and acceptable to the Engineer.
   2. Do not patch, repair, or cover defective Work without prior inspection by the Engineer.
   3. Preparation of concrete for repair:
      a. Make no repair until Engineer has accepted methods for preparing surfaces and for making and curing repairs.
      b. Chip out and key-in imperfections in the Work to make them ready for repair.
      c. Coat bonding surfaces and edges of repair area with one of the following bonding agents as accepted by the Engineer.
         1) Epoxy bonding agent as specified in Section 03071 - Epoxies; or
         2) Epoxy resin/Portland cement bonding agent as specified in Section 03072 - Epoxy Resin/Portland Cement Bonding Agent.
   4. Methods of repair:
      a. Dry pack mortar method:
         1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.

2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
3) Install dry-pack mortar as specified in Section 03600 - Grouting.

b. Cement mortar method:
1) Use for holes too wide to dry pack and too shallow for concrete replacement; and for comparatively shallow depressions, large or small, that extend no deeper than nearest surface reinforcement.
2) Install cement mortar as specified in Section 03600 - Grouting.

c. Concrete replacement:
1) Use when holes extend entirely through the concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
2) Form, place, consolidate, and cure concrete of same mix as the surrounding work.

END OF SECTION

## ATTACHMENT A - MENZEL FORMULA AND NOMOGRAPH

## MENZEL FORMULA AND NOMOGRAPH

Source: ACI PRC-350

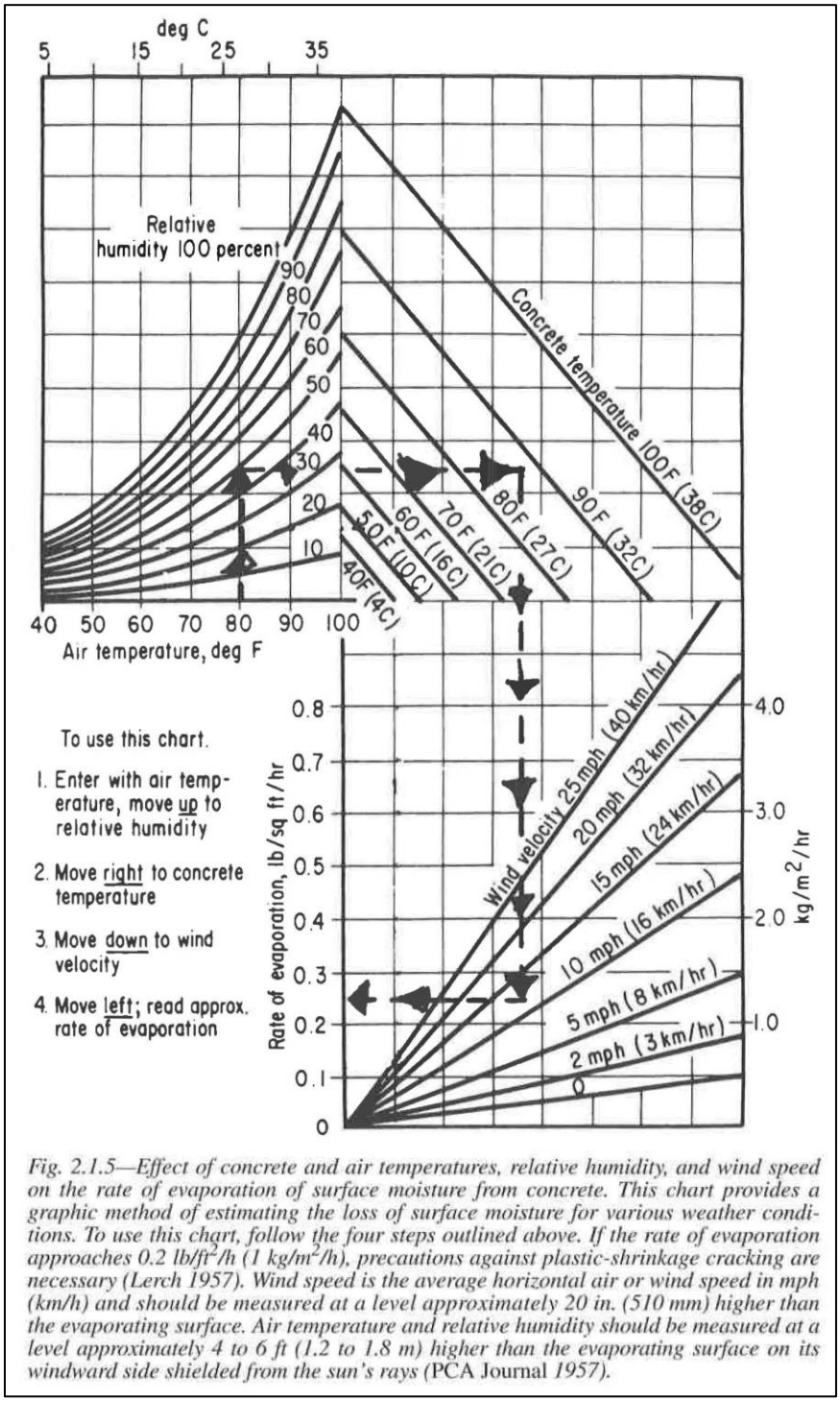



*Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind speed on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use this chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/h (1 kg/m²/h), precautions against plastic-shrinkage cracking are necessary (Lerch 1957). Wind speed is the average horizontal air or wind speed in mph (km/h) and should be measured at a level approximately 20 in. (510 mm) higher than the evaporating surface. Air temperature and relative humidity should be measured at a level approximately 4 to 6 ft (1.2 to 1.8 m) higher than the evaporating surface on its windward side shielded from the sun's rays (*PCA Journal *1957).*

## ATTACHMENT B - COARSENESS FACTOR CHART

**COARSENESS FACTOR CHART**

Source: ACI PRC-302.1-15, Figure 8.9.2.2.

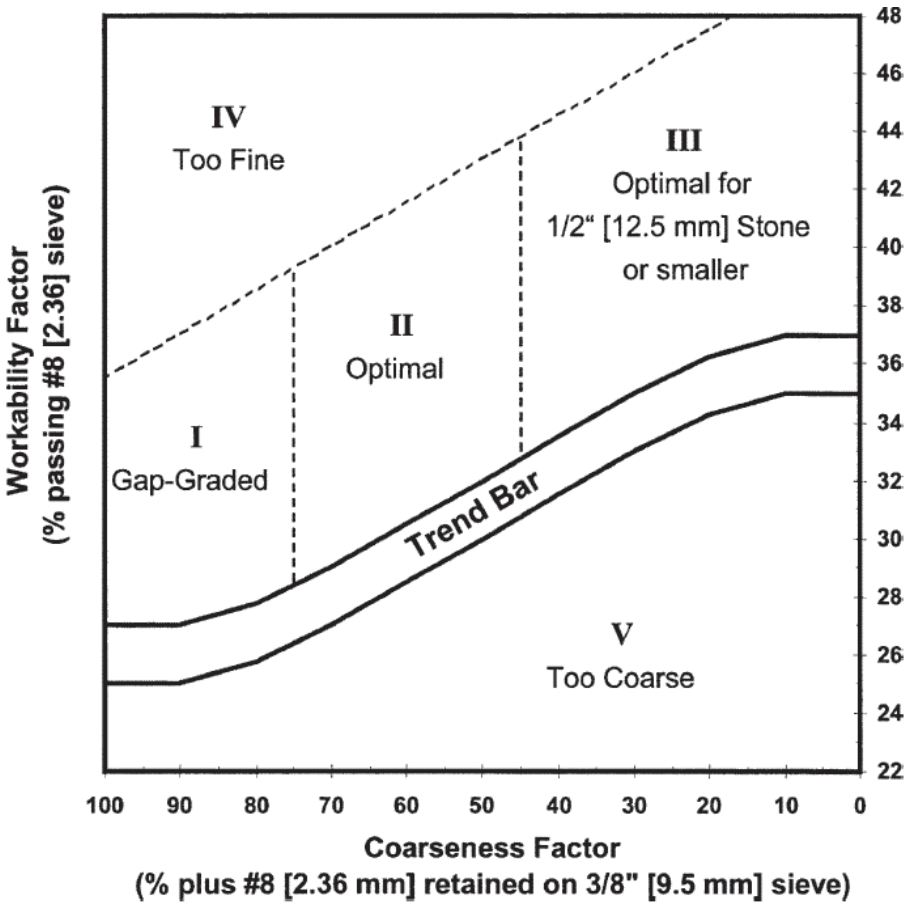
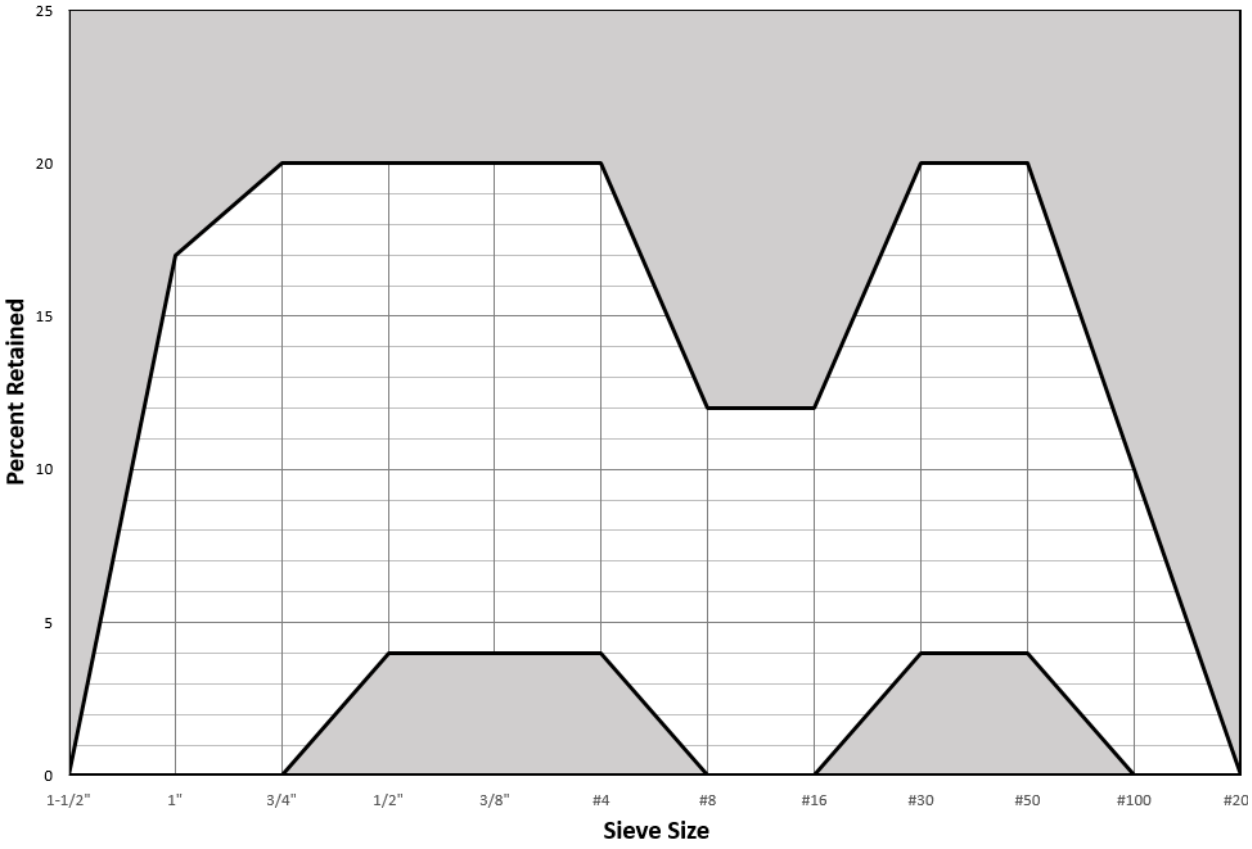



*Fig. 8.9.2.2—Coarseness factor chart for evaluating potential performance of mixture.*

## ATTACHMENT C - COMBINED AGGREGATE GRADATION CHART

## COMBINED AGGREGATE GRADATION CHART



## ATTACHMENT D - CONCRETE PLACEMENT CHECKLIST

## CONCRETE PLACEMENT CHECKLIST

Project: _____ Class of Concrete: _____
Project No.: _____ Test Cylinders Taken? Yes: _____ No: _____

| Preparation Slab | Contractor | N/A |
|---|---|---|
| Compaction Subgrade | | |
| Filter Fabric/Drain Rock-ABC/Separator Fabric | | |
| Drain Rock, Pea Gravel & Void Form | | |
| Starter Wall Forms | | |
| Reinforcing Steel | | |
| Screeds | | |

| Embedded Items | Contractor | N/A |
|---|---|---|
| A. Anchor Bolts | | |
| B. Water Stop | | |
| C. Rebar | | |
| D. Electrical | | |
| E. Plumbing Rough-in | | |
| F. Mechanical | | |
| G. HVAC | | |

| Concrete Placement Equip. | Contractor | N/A |
|---|---|---|
| A. Crane | | |
| B. Buckets | | |
| C. Hoppers | | |
| D. Vibrators | | |
| E. Elephant trunks | | |
| F. Floodlights | | |
| G. Pump Truck | | |

| Building Department Notification | |
|---|---|
| Date: | Time: |

| Prep Wall Concrete | Contractor | N/A |
|---|---|---|
| Access To Work | | |
| Ladders Secured | | |
| Clean up and Washed Out | | |
| Reinforcing Steel | | |
| | | |

| Forms | Contractor | N/A |
|---|---|---|
| A. Alignment & Grade | | |
| B. Scaffolding | | |
| C. Sleeves & Wall Castings | | |
| D. Embedded Items | | |
| E. Electrical | | |
| F. Plumbing Rough-in | | |
| G. Piping | | |

| Record of Curing Conditions During Placement | |
|---|---|
| | Start: Finish: |
| Date: | |
| Time: | |
| Weather: | |
| Temperature: | |
| Comments: | |

Location of Placement _____

The Contractor certifies the above-proposed concrete placement is prepared as indicated and is in accord with the Contract Drawings and Specifications. The Contractor requests permission to begin placement of concrete on the date of _____ at _____. The estimated number of yards is _____. The estimated duration of the placement is _____.

By: _____
Contractor

Released for placement by: _____
Engineer

## SECTION 03366

## TOOLED CONCRETE FINISHING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Tooled concrete finishes.

### 1.02 QUALITY ASSURANCE

A. Mock-ups:
   1. Test panels for concrete finishes:
      a. Prepare test panels for F4 and F5 finishes and tie-hole repairs for review by Engineer.
      b. Accepted test panels serve as standard of quality and workmanship for project.
   2. Prepare test panel showing horizontal and vertical joints proposed for project for review by the Engineer. Refer to finishes specified in this Section.
   3. Test panels indicating methods for making concrete repairs: Prepare test panels for proposed repairs at beginning of project for review by Engineer:
      a. Accepted test panels serve as standard for repairs during the project.

### 1.03 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 MIXES

A. Mortar mix for F4 finish: Consist 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.

B. Mortar mix for F5 finish: Consist of 1 part cement to 1-1/2 parts of sand which passes Number 16 screen.

## PART 3 EXECUTION

### 3.01 CONCRETE FINISHES

A. Cement for finishes:
   1. Addition of white cement may be required to produce finish which matches color of concrete to be finished.

B. Finish vertical concrete surfaces with one of the following finishes as indicated in the Finish Schedule:
   1. F1 finish: No special treatment other than repair defective work and fill depressions 1 inch or deeper and tie holes with mortar after removal of curing compound.
   2. F2 finish: No special treatment other than repair defective work, remove fins, fill depressions 1/2 inch or deeper and tie holes with mortar after removal of curing compound.
   3. F3 finish: Repair defective work, remove fins, offsets, and grind projections smooth. Fill depressions 1/4 inch or larger in depth or width and tie holes with mortar after removal of curing compound.
   4. F4 finish: Receive same finish as specified for F3 finish, and, in addition fill depressions and holes 1/16 inch or larger in width with mortar.
      a. "Brush-Off" sandblast surfaces prior to filling holes to expose all holes near surface of the concrete.
      b. Thoroughly wet surfaces and commence filling of pits, holes, and depressions while surfaces are still damp.
      c. Perform filling by rubbing mortar over entire area with clean burlap, sponge rubber floats, or trowels.
      d. Do not let any material remain on surfaces, except that within pits and depressions.
      e. Wipe surfaces clean and moist cure.
   5. F5 finish: Receive same finish as specified for F3 finish, and, in addition, receive special stoned finish, in accordance with following requirements:
      a. Remove forms and perform required repairs, patching, and pointing as specified in this Section.
      b. Wet surfaces thoroughly with brush and rub with hard wood float dipped in water containing 2 pounds of portland cement per gallon.
      c. Rub surfaces until form marks and projections have been removed.
      d. Spread grindings from rubbing operations uniformly over surface with brush in such manner as to fill pits and small voids.
      e. Moist cure brushed surfaces and allow to harden for 3 days:
         1) After curing, obtain final finish by rubbing with carborundum stone of approximately Number 50 grit until entire surfaces have smooth texture and are uniform in color.
         2) Continue curing for remainder of specified time.
      f. If any concrete surface is allowed to become too hard to finish in above specified manner, sandblast and wash related surfaces exposed to view, whether finished or not.
         1) While still damp, rub over surface, plastic mortar, as specified for brushed surfaces and handstoned with Number 60 grit carborundum stone, using additional mortar for brushed surfaces until surface is evenly filled without an excess of mortar.
         2) Continue stoning until surface is hard.
         3) After moist curing for 3 days, make surface smooth in texture and uniform in color by use of Number 50 or Number 60 grit carborundum stone.
         4) After stoning, continue curing until 7 day curing period is completed.

C. Finish horizontal concrete surfaces with one of the following finishes as indicated in the Finish Schedule after proper and adequate vibration and tamping:
   1. S1 finish: Screeded to grade and leave without special finish.
   2. S2 finish: Smooth steel trowel finish.
   3. S3 finish: Steel trowel finish free from trowel marks. Provide smooth finish free of all irregularities.
   4. S4 finish: Steel trowel finish, without local depressions or high points, followed by light hairbroom finish. Do not use stiff bristle brooms or brushes. Perform brooming parallel to slab-drainage. Provide resulting finish that is rough enough to provide nonskid finish. Finish is subject to review and acceptance by the Engineer.
   5. S5 finish: Nonslip abrasive: After concrete has been screeded level and hardened enough to support man standing on a board, sprinkle abrasive from shake screen into surface at uniform rate of 25 pounds for each 100 square feet of surface area, wood float into finish, then trowel abrasive into surface with steel trowel properly exposing abrasive in surface as required to provide nonslip surface.
   6. S6 finish: Roughened finish: After concrete has been screeded to grade, apply a roughened finish by use of a jitterbug roller or similar device.

D. Finish concrete floor surfaces to which surfacing material is applied: Finish smooth with tolerance within 1/8 inch in 10 feet in any direction from lines indicated on the Drawings.

## 3.02 CONCRETE FINISH SCHEDULE

A. Finish concrete surfaces as follows:
   1. F4 finish for following vertical surfaces:
      a. Concrete surfaces specified or indicated to be painted.
      b. Concrete surfaces, interior or exterior, exposed to view.
   2. Surfaces in open channels, basins, and similar structures:
      a. F3 finish for vertical surfaces which are normally below water surface.
      b. F4 finish for vertical surfaces located above normal water surface and exposed to view.
      c. Remove fins and fill tie holes from concrete surfaces located in closed boxes or channels where there is normally no access or passageway.
   3. S1 finish for following surfaces:
      a. Projecting footings which are to be covered with dirt.
      b. Slab surfaces which are to be covered with concrete fill.
   4. S2 finish for following surfaces:
      a. Tops of corbels.
      b. Tops of walls and beams not covered above in this Section.
      c. Tops of slabs not covered above in this Section.
      d. All other surfaces not specified to be finished otherwise.
   5. S3 finish for following surfaces:
      a. Building and machine room floors which are not covered with surfacing material: Provide floors that are free from trowel marks.
   6. S4 finish for following surfaces:
      a. Exterior walkways.
      b. Tops of exterior walls or beams which are to serve as walkways.
      c. Tops of exterior walls or beams which are to support gratings.

d. Top surface of slabs for basins, channels, digesters, and similar structures.

7. S6 finish for following surfaces:
   a. Basin bottoms, or other similar slab surfaces, over which layer of basin bottom grout will be applied.

END OF SECTION

# SECTION 03600

# 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. Master Builder Solutions, MasterFlow 648.
      c. L&M Construction Chemicals, Inc., EPOGROUT.
   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. Master Builder Solutions, MasterFlow 928.
      c. L&M Construction Chemicals, Inc., CRYSTEX.

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 03300 - Cast-in-Place Concrete.
        b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.

D. Epoxy grout:
    1. Consist of mixture of epoxy or epoxy gel and sand.
        a. Epoxy: As specified in Section 03071 - Epoxies.
        b. Epoxy gel: As specified in Section 03071 - 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 03300 - Cast-in-Place Concrete.
    b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.

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: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:
   1. General:
      a. Use non-shrink grout as specified in this Section.
      b. Baseplate grouting shall take place from one 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 one 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 05120

# STRUCTURAL STEEL

## 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. 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. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
10. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
11. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
12. A992 - Standard Specification for Structural Steel Shapes.
13. F436 - Standard Specification for Hardened Steel Washers.
14. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
15. F594 - Standard Specification for Stainless Steel Nuts.
16. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
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.
19. 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. Snug-tight: 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 for field welds: 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 and D1.6.
      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 and D1.6 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 and D1.6.
   **3.** Steel fabricator's AISC certification.

D. Test reports:
   1. 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. All steel work shall be in accordance with the AISC Code of Standard Practice for Structural Steel Buildings and Bridges, AISC 303.

B. Certification:
   1. Steel fabricators shall be certified by the AISC or other certification acceptable to the Engineer and the building official having jurisdiction.

C. Welding:
   1. Perform welding of structural metals in accordance with AWS D1.1 and D1.6 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.

3. Stainless steel:
    a. Units descaled, pickled, and passivated as specified in “Fabrication” in this Section.
    b. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship all thread rods with properly fitting nuts attached.
    c. Alloy Type 304 or Type 316 as indicated on the Drawings.
    d. Type 304:
        1) Rod: ASTM F593, Group 1, Condition CW, coarse threads.
        2) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
        3) Washers: Type 304 stainless steel.

        Type 316:
        4) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
        5) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
        6) Washers: Type 316 stainless steel.

C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

D. High-strength bolts:
1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators.
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 A325and 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.

E. 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.
5. Welded studs: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## 2.03 ISOLATING SLEEVES AND WASHERS

A. As indicated on the Drawings and as specified in Section 05190 - 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, the connection shall be designed by a licensed engineer working for the fabricator.
   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 Sections 09910 - Painting and 09960 - 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. Welding - stainless steel:
   1. General: In accordance with AWS D1.6.
   2. Field welding of stainless steel will not be permitted.
   3. Passivation of field-welded surfaces:
      a. Provide cleaning, pickling and passivating as specified under “Fabrications” of this Section. Clean using Derustit Stainless Steel Cleaner, or equal.

F. 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 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

G. 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 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snug-tight" condition.
3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.
4. All thread rods in drilled holes bonded to masonry with adhesive: Install as specified in Section 04055 - Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry.

H. 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 snug tight connections at bolted connections, except where slip-critical or pretensioned 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: Snug-tight:
    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.

I. Fasteners: Stainless steel bolts:
1. Connections shall be snug-tight 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 overtightening.

## 3.03 FIELD QUALITY CONTROL

A. Provide quality control as specified in Section 01450 - Quality Control.

## 3.04 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01455 - Regulatory Quality Assurance.

END OF SECTION

# SECTION 05140

# STRUCTURAL ALUMINUM

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   2. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
   3. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

B. American Welding Society (AWS):
   1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
   2. D1.2 - Structural Welding Code - Aluminum.

### 1.03 SUBMITTALS

A. Quality control submittals:
   1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
   2. Welder's certificates.

### 1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
   2. Notify Engineer 24 hours minimum before starting shop or field welding.
   3. Engineer may check materials, equipment, and qualifications of welders.
   4. Remove welders performing unsatisfactory work, or require to requalify.
   5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
   6. Contractor shall bear costs of retests on defective welds.
   7. Contractor shall bear costs in connection with qualifying welders.

## PART 2 PRODUCTS

### 2.01 MATERIALS

A. Structural sheet aluminum: ASTM B209, Alloy 6061-T6.

B. Structural aluminum: ASTM B308, Alloy 6061-T6.

C. Extruded aluminum: ASTM B221, Alloy 6063-T42.

D. Isolating sleeves and washers:
   1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

E. Miscellaneous materials:
   1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
   2. Size, form, attachment, and location shall conform to the best of current practice.
   3. Conform to applicable ASTM Standards for materials not otherwise specified.

### 2.02 FABRICATION

A. Aluminum layout:
   1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
   2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.

B. Cutting aluminum:
   1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
   2. Material more than 1/2-inch thick: Saw or rout.
   3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
   4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
   5. Do not flame cut aluminum alloys.
   6. Punch or drill rivet or bolt holes to finished size before assembly:
      a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
      b. Make holes cylindrical and perpendicular to principal surface.
      c. Do not permit holes to drift in a manner to distort metal.

C. Aluminum forming and assembly:
   1. Do not heat structural aluminum, except as follows:
      a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
      b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.

D. Before assembly, remove chips lodged between contacting surfaces.

E. Welding aluminum:
   1. Perform welding of aluminum in accordance with AWS D1.2.
   2. Weld aluminum in accordance with the following:
      a. Preparation:
         1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
         2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
         3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
         4) Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
      b. Filler metal: Aluminum alloys conforming to the requirements of AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      c. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
      e. Do not use welding process that requires use of a welding flux.
      f. Neatly make welded closures.
      g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
      h. Make welds full penetration welds unless otherwise indicated on the Drawings.

## 2.03 FINISHES

A. Coating for dissimilar metals:
   1. Epoxy mastic
      a. As specified in Section 09960 - High-Performance Coatings, coating system EPX-M-5.

# 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 INSTALLATION

A. Install structural aluminum products as indicated on the Drawings and specified.

B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.

C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.

D. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and true to level.

E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.

F. Interface with other products:
   1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Coat those parts of aluminum that will be cast into concrete or that will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09960 - High-Performance Coatings.

END OF SECTION

## SECTION 05190

## MECHANICAL ANCHORING AND FASTENING TO CONCRETE

## TABLE OF CONTENTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
      b. Anchor rods.
      c. Concrete inserts.
      d. Deformed bar anchors.
      e. Welded studs.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.
      b. Sleeve anchors.
      c. Screw anchors.
      d. Undercut concrete 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. Cast-in anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

B. 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.

C. 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.

D. Post-installed anchor: Fastener or assembly installed in hardened concrete construction, typically by drilling into the structure and inserting a steel anchor assembly.

E. 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.
    b. Exterior and interior locations at the following treatment structures:
        1) Wastewater treatment facilities: Liquids stream:
            a) Raw wastewater delivery and holding structures.
            b) Equalization Basins.
            c) Clarifiers.
            d) Bioreactors.
            e) Chem-Phos Building.
            f) Pump rooms and vaults.
        2) Wastewater treatment facilities: Solids stream:
            a) Advanced Treatment Building.

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 01330 - 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 01410 - Regulatory Requirements.
            b) That testing of the concrete anchor included the simulated seismic tension and shear tests of AC193, and that the anchor is accepted for use in Seismic Design Categories C, D, E, or F and with cracked concrete.
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 01410 - Regulatory Requirements.
    2. Installers: Post-installed mechanical anchors:
        a. Conduct a training session with the manufacturer's authorized technical representative for the project on-site:
            1) Training shall cover the complete installation process for each type of anchor to be used and shall include, but not be limited to, hole drilling procedures and techniques, hole preparation and cleaning, bolt installation, and bolt proof loading and torquing.
            2) Use only trained and qualified personnel for anchor installation.
        b. Installations shall be performed by trained installers having at least 3 years of experience performing similar installations with similar types of anchors.

B. Special inspection:
    1. Provide special inspection of post-installed anchors as specified in Section 01455 - Regulatory Quality Assurance and this Section.

## 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.

## 1.07 PROJECT CONDITIONS

A. Seismic Design Category (SDC) for structures is indicated on the Drawings.

# 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.

B. Anchor rods:
1. Description: Straight steel rod having threads on each end or continuously threaded from end to end. One threaded end is fitted with nuts or plates and embedded in concrete to the effective depth indicated on the Drawings, leaving the opposite threaded end to project clear of the concrete face as required for the connection to be made at that location.
2. Materials:
    a. Stainless steel: Type 316:
        1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
        2) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
        3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of rods.
        4) Washers: Type 316 stainless steel.
        5) Plates (embedded): ASTM A240.
    b. Stainless steel: Type 304:
        1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
        2) Rod: ASTM F593, Group 1, Condition CW, coarse threads.
        3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads or rods.
        4) Washers: Type 304 stainless steel.
        5) Plates (embedded): ASTM A240.
    c. Galvanized: steel:
        1) Hot-dip galvanized with coating in accordance with ASTM F2329.
        2) Rod: ASTM F1554, Grade 36, coarse thread.
        3) Nuts: ASTM A563, Grade A, threads to match rod.
        4) Washers: ASTM F436, Type 1.
        5) Plates (embedded): ASTM A36.

C. Concrete insert: Ductile embed:
1. Description: 1-piece, integrally hot forged sleeve for embedment in concrete. Provided with flange for nailing to forms and female threaded coupler at the exposed concrete face, and washer-faced hex headed foot to resist pullout from concrete at the embedded end.
2. Manufacturers: The following or equal:
    a. Dayton Superior, F-54 Ductile Embed Insert.

3. Materials:
    a. Stainless steel: Not available.
    b. Galvanized steel:
        1) Hot-dip galvanized coating in accordance with ASTM A123 or A153.
        2) Steel: ASTM A29 hot rolled, Grade 1045.

D. Deformed bar anchors:
1. Description: Steel rod with rebar-like deformations along its length and welding ferrule at one end for attachment to structural steel members (plates or shapes).
2. Manufacturers: One of the following or equal:
    a. Nelson Stud Welding Co., D2L Deformed Bar Anchors (D2L-DBA).
    b. Stud Welding Products, Inc., Deformed Anchor Studs.
3. Materials:
    a. Stainless steel: Not available.
    b. Galvanized steel:
        1) Hot-dip galvanized coating in accordance with ASTM A153 where indicated on the Drawings.
        2) Steel: ASTM A1064 wire deformed for concrete reinforcement.

E. Welded studs:
1. Description: Anchor with forged head for embedment into concrete on one end, and welding ferrule for attachment to steel on the other. Welded to steel members or plates to provide anchorage for steel connections to concrete.
2. Acceptance criteria:
    a. Welded studs in accordance with AWS D1.1, Type B.
3. Manufacturers: One of the following or equal:
    a. Nelson Stud Welding Co., H4L Concrete Anchors or S3L Shear Connectors as indicated on the Drawings.
    b. Stud Welding Products, Headed Concrete Anchors (HCA) or Headed Shear Connectors (HSC) as indicated on the Drawings.
4. Materials:
    a. Steel: Carbon steel in accordance with ASTM A108 with 50,000 pounds per square inch minimum yield strength, and 60,000 pounds per square inch minimum tensile strength.

F. Steel plates or shapes for fabrications including assemblies with welded studs or deformed bar anchors:
1. Stainless steel: Type 316L or Type 304L:
    a. Plates (embedded): ASTM A240.
2. Galvanized steel:
    a. Hot dip galvanized in accordance with ASTM A123.
    b. Steel: ASTM A36.

## 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 03055 - 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 01410 - 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 Utah.
      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.
         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: Not available.
    2) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5) or equal.

F. Undercut concrete anchors:
1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creation of an undercut “key” at the embedded end of the anchor. The undercut may be achieved with a special drill before anchor installation, or by the anchor itself during installation.
2. Acceptance criteria:
    a. Acceptance criteria:
        1) Undercut 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 ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
        2) Undercut anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
    b. Use pre-setting units.
3. Manufacturers: One of the following or equal:
    a. Hilti, HDA (carbon steel) or HDA-R (stainless steel) Undercut Anchor.
    b. Powers Fasteners, Atomic+ Undercut Anchor.
    c. Simpson Strong-Tie, Torq-Cut Anchor.
    d. USP Structural Connectors, DUC-L Undercut Anchors.
4. Materials:
    a. Stainless steel: Corrosive, wet, and moist and locations: Type 316.
    b. Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

## 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: Construct as specified in Section 05500 - Metal Fabrications:
    a. At galvanized carbon steel anchor bolts, provide galvanized carbon steel sleeves.
    b. At stainless steel anchor bolts, provide stainless steel sleeves of same Type (304 or 316) as bolt, except that sleeves shall be constructed from low carbon stainless steel for welding (Type 304L or 316L).

B. Forged steel hardware:
    1. See Section 05120 - 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 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 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.

C. Anchor rods:
1. Install as specified for anchor bolts.

D. Concrete inserts:
1. Provide inserts with minimum clear concrete cover not less than that specified for reinforcing bars.

E. Deformed bar anchors:
1. Butt weld to steel fabrications with automatic stud welding gun as recommended by manufacturer.
2. Ensure that butt weld develops the full strength of the anchor.

F. Welded studs:
1. Butt weld to steel fabrications with automatic stud welding gun as recommended by the manufacturer.
2. Ensure that butt weld develops full strength of the stud.

## 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 03055 - 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, do not:
   a. Remove and reuse/reinstall anchors.
   b. Loosen or remove bolts or studs.

B. Holes drilled into concrete:
1. Do not drill holes in concrete until the material has achieved its minimum specified compression strength (f'c).

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.
    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:

| Nominal Diameter | Minimum Member Thickness | |
|---|---|---|
| | In Concrete | |
| 3/8 inch | 2 1/2 inch | 8 inch |
| 1/2 inch | 3 1/2 inch | 8 inch |
| 5/8 inch | 4 1/2 inch | 10 inch |
| 3/4 inch | 5 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:

| Nominal Diameter | Minimum Member Thickness | |
|---|---|---|
| | In Concrete | |
| M8 (1/2 inch) | 70 mm (2 3/4 inch) | 100 mm (8 inch) |
| M10 (5/8 inch) | 76 mm (3 inch) | 250 mm (10 inch) |
| M12 (3/4 inch) | 80 mm (3 1/4 inch) | 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:

| Nominal Diameter | Minimum Member Thickness | |
|---|---|---|
| | In Concrete | |
| 3/8 inch | 2 1/2 inch | 8 inch |
| 1/2 inch | 3 1/4 inch | 8 inch |
| 5/8 inch | 4 inch | 10 inch |
| 3/4 inch | 5 1/2 inch | 12 inch |

2. 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.

H. Undercut concrete anchors:
1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

| Nominal Diameter (bolt) | Minimum Member Thickness[(1)] | |
|---|---|---|
| | In Concrete | |
| M10 (3/8 inch) | 100 mm (4 inch) | 200 mm (8 inch) |
| M12 (1/2 inch) | 125 mm (5 inch) | 350 mm (14 inch) |
| M16 (5/8 inch) | 190 mm (7 1/2 inch) | 460 mm (18 inch) |
| M20 (7/8 inch) | 250 mm (10 inch) | 510 mm (20 inch) |

2. Installations of undercut anchors shall not be allowed where edge distances are less than 12 times the nominal diameter of the anchor stud.
3. Undercut bottom of hole using cutting tools manufactured for this purpose by the manufacturer of the undercut anchors being placed.

## 3.06 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section as specified in Section 01450 - 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. Owner's Representative other than the Contractor will 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 Owner.

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.
   1. Provide special inspection during positioning of anchors and placement of concrete around the following anchors:
      a. Anchor bolts.
      b. Anchor rods.
      c. Concrete inserts (all types).
      d. Deformed bar anchors.
      e. Welded studs.
   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 surrounding the anchors, provide periodic special inspection to observe and confirm the following:
   a. Base material (concrete):
      1) Solid and dense concrete 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.
   1. Provide special inspection during installation of the following anchors:
      a. Concrete anchors.
      b. Sleeve anchors.
      c. Screw anchors.
      d. Undercut concrete 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 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. Owner's Representative 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 Owner 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 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 Owner.

## 3.09 SCHEDULES

A. Provide and install anchor materials as scheduled in the following Table.

**Table - Required Anchoring Materials by Location**

| Location/Exposure | | Materials | Notes |
|---|---|---|---|
| **1.** | **Anchors into concrete for attachment of carbon steel, including structural steel and other steel fabrications:** | | |
| a) | Interior dry areas | Carbon steel - galvanized | |
| b) | Locations with galvanized steel structures or fabrications | Stainless steel - Type 304 or 316 | 1 |
| c) | Exterior and interior wet and moist locations | Stainless steel - Type 316 | 1 |
| d) | Corrosive locations | Stainless steel - Type 316 | 1 |
| **2.** | **Anchors into concrete for attachment of aluminum, stainless steel, or fiber-reinforced plastic (FRP) shapes and fabrications:** | | |
| a) | Interior dry areas | Stainless steel - Type 304 or 316 | 1 |
| b) | Exterior and interior wet and moist locations | Stainless steel - Type 316 | 1 |

| Table - Required Anchoring Materials by Location | | | |
|---|---|---|---|
| **Location/Exposure** | | **Materials** | **Notes** |
| c) | Corrosive locations | Stainless steel - Type 316 | 1 |
| **3.** | **Anchors for attaching equipment and its appurtenances:** | | |
| a) | All locations | Stainless steel - Type 316 (unless Type 304 is specifically indicated in the specifications for the equipment.) | 1 |

Notes:
(1) Where anchors are in contact with a metal that differs from that of the anchor, provide isolation sleeves and washers.

END OF SECTION

## SECTION 05500

## METAL FABRICATIONS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Aluminum grating stair tread.
   2. Aluminum stair nosing.
   3. Cast iron stop plank grooves.
   4. Concrete inserts.
   5. Handrails and guardrails.
   6. Ladders.
   7. Manhole frames and covers.
   8. Metal gratings.
   9. Metal tread plate.
   10. Preformed channel pipe supports.
   11. Stairs.
   12. Miscellaneous metals.
   13. Associated accessories to the above items.

### 1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45: Designations from Start to Finish.
      a. M12-C22-A41.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

C. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   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. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
14. A992 - Standard Specification for Structural Steel Shapes.
15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

D. American Welding Society (AWS):
1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.

E. Occupational Safety and Health Administration (OSHA).

## 1.03 DEFINITIONS

A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

## 1.04 SUBMITTALS

A. Product Data:
1. Aluminum grating stair tread.
2. Aluminum stair nosing.
3. Cast iron stop plank grooves.
4. Handrails and guardrails.
5. Manhole frames and covers.
6. Metal grating.

B. Shop drawings:
1. Handrails and guardrails:
a. Including details on connection attachments, gates, kick plates, ladders, and angles.
b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
c. Include erection drawings, elevations, and details where applicable.

d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.

2. Ladders.
3. Metal grating.
4. Metal tread plate.
5. Stairs.
6. Miscellaneous metals.

C. Samples:
1. Guardrails with specified finishes.

D. Quality control submittals:
1. Design data.
2. Calculations:
a. Stairs: Calculations for anchoring stairs to concrete walls and elevated concrete slabs stamped by a Professional Engineer registered in the state of Utah.
3. Test reports:
a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.
b. Gratings:
1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
2) Reports of tests performed.
c. Planks:
1) Plank manufacturers' calculations showing that planks will meet specified load bearing and deflection requirements for each size plank for each span.
2) Reports of tests performed.

## PART 2 PRODUCTS

### 2.01 MATERIALS

A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

| Item | ASTM Standard No. | Class, Grade Type or Alloy No. |
|---|---|---|
| **Cast Iron** | | |
| Cast Iron | A48 | Class 40B |

| Item | ASTM Standard No. | Class, Grade Type or Alloy No. |
|---|---|---|
| **Steel** | | |
| Galvanized sheet iron or steel | A653 | Coating G90 |
| Coil (plate) | A635 | -- |
| Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes). | A36 | -- |
| Rolled W shapes | A992 | Grade 50 |
| Standard bolts, nuts, and washers | A307 | -- |
| High strength bolts, nuts, and hardened flat washers | F3125, Grade A325 | -- |
| Eyebolts | A489 | Type 1 |
| Tubing, cold-formed | A500 | -- |
| Tubing, hot-formed | A501 | -- |
| Steel pipe | A53 | Grade B |
| **Stainless Steel** | | |
| Plate, sheet, and strip | A240 | Type 304* or 316** |
| Bars and shapes | A276 | Type 304* or 316** |
| Bolts (Type 304) | F593 | Group 1 Condition CW |
| Bolts (Type 316) | F593 | Group 2 Condition CW |
| **Aluminum** | | |
| Flashing sheet aluminum | B209 | Alloy 5005-H14, 0.032 inches minimum thickness |
| Structural sheet aluminum | B209 | Alloy 6061-T6 |

| Item | ASTM Standard No. | Class, Grade Type or Alloy No. |
|---|---|---|
| Structural aluminum | B209<br>B308 | Alloy 6061-T6 |
| Extruded aluminum | B221 | Alloy 6063-T42 |
| * Use Type 304L if material will be welded.<br>** Use Type 316L if material will be welded. | | |

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

## 2.02 MANUFACTURED UNITS

A. Aluminum grating stair tread:
   1. Manufacturers: One of the following or equal:
      a. Harsco Industrial IKG, Aluminum Grating Stair Tread with Mebac® nosing.
      b. McNichols Co., Type A-Standard with Corrugated Angle Nosing.
   2. Material: Welded aluminum grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers.
   3. Size:
      a. Tread width: To equal tread spacing plus 1 inch minimum.
      b. Tread length: Length to suit stringer-to-stringer dimension on the Drawings.
      c. Depth: 1-3/4 inches.
   4. Bolts: Type 316 stainless steel.

B. Aluminum stair nosing:
   1. Manufacturers: One of the following or equal:
      a. Wooster Products, Inc., Type 101 Nosing.
      b. American Safety Tread Co., Inc., Style 801 Nosing.
   2. Material: Cast aluminum abrasive nosings with aluminum oxide granules integrally cast into metal, forming permanent, nonslip, long-wearing surface.
   3. For installation in cast-in-place stairs.
   4. Configuration: 4 inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.

C. Cast iron stop plank grooves:
   1. Manufacturers: One of the following or equal:
      a. Neenah Foundry Co., R-7500 Series, Type A.
      b. McKinley Iron Works, Type L.
   2. Size: 2-inch wide groove opening by 1-1/2 inch deep, unless otherwise indicated on the Drawings.
   3. Recess groove with the cast iron surface of the groove set flush with the concrete surface.

D. Concrete inserts:
   1. Concrete inserts for supporting pipe and other applications are specified in Section 15061 - Pipe Supports.

E. Handrails and guardrails:
   1. General:
      a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.
      b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators:
         1) Indicate on the shop drawings locations of such equipment.
         2) Highlight locations where railings cannot be made continuous, and obtain Engineer's directions on how to proceed before fabricating or installing railings.
   2. Aluminum handrails and guardrails (nonwelded pipe):
      a. Rails, posts, and fitting-assembly spacers:
         1) In accordance with ASTM B429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
      b. Kick plates: 6061 or 6105 aluminum alloy.
      c. Fastenings and fasteners: As recommended or furnished by the manufacturer.
      d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
         1) Fabrications: In accordance with ASTM B209 or ASTM B221 extruded bars:
            a) Bases: 6061 or 6063 extruded aluminum alloy.
         2) Plug screws or blind rivets: Type 305 stainless steel.
            a) Other parts: Type 300 series stainless steel.
      e. Finish of aluminum components:
         1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
         2) Pretreat aluminum for cleaning and removing markings before anodizing.
      f. Fabrication and assembly:
         1) Fabricate posts in single, unspliced pipe length.
         2) Perform without welding.
         3) Do not epoxy bond the parts.
         4) Maximum clear opening between assembled railing components as indicated on the Drawings.
      g. Manufacturers: One of the following or equal:
         1) Moultrie Manufacturing Co., Wesrail.
         2) Golden Railings, Riveted System.
         3) Craneveyor Corp. Enerco Metals, C-V Rail.
   3. Picket railing: Manufacturers: One of the following or equal:
      a. Julius Blum and Co., equivalent product.
      b. Craneveyor Corp., RailTec 400.

4. Steel pipe handrails and guardrails:
    a. Schedule 40 black steel pipe with minimum 1.9-inch outside diameter, or larger where indicated on the Drawings.
    b. Fabricate posts in single, unspliced pipe length.
    c. Kick plates: Galvanized steel.
    d. Attachment devices: Provide clip angles and other fasteners necessary for securing handrails and guardrails to other construction as indicated on the Drawings.
    e. Continuously weld joints and grind smooth.
    f. Bend rails to profile indicated on the Drawings, without sharp bends or flat spots. Rails shall be round after bending.
    g. Neatly weld intersection of rails and posts, and grind surfaces smooth.
5. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.

F. Ladders:
1. General:
    a. Type: Safety type conforming to local, State, and OSHA standards as minimum. Furnish guards for ladder wells.
    b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.
2. Aluminum ladders:
    a. Materials: 6063-T5 aluminum alloy.
    b. Rungs:
        1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.
        2) Capable of withstanding 1,000 pound load without failure.
    c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
    d. Finish of aluminum components:
        1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
        2) Pretreat aluminum for cleaning and removing markings before anodizing.
    e. Fabrication:
        1) Welded construction, of size, shape, location, and details indicated on the Drawings.
        2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and OSHA requirements.
    f. Fall prevention system: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying OSHA safe climbing requirements:
        1) Manufacturers: One of the following or equal:
            a) North Consumer Products, Saf-T-Climb.
            b) Swager Communications, Climbers Buddy System.

G. Manhole frames and covers:
1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.

3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
4. Frame:
    a. Bottom flange type.
    b. Approximately 4-1/2 inches frame height.
    c. Dimensions as indicated on the Drawings.
        1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.
5. Cover:
    a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as "ELECTRICAL," "SEWER," "TELEPHONE," or "WATER."
    b. Solid type without ventilation holes.
6. Finish: Unpainted.

H. Metal gratings:
1. General:
    a. Fabricate grating to cover areas indicated on the Drawings.
    b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
    c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.
    d. Band ends of grating and edges of cutouts in grating:
        1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
        2) Cutout banding: Full height of grating.
        3) Use banding of same material as grating.
        4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
        5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
        6) Openings smaller than 6 inches: Locate opening at edge of single panel.
        7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
        8) Fabricate steel grating sections in units weighing not more than 50 pounds each.
        9) Fabricate aluminum grating sections in units of weighing not more than 50 pounds each.
        10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.
    e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
        1) Furnish a suitable dial gauge for measuring deflections.
    f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.

2. Aluminum grating:
    a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
    b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
    c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
    d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.
    e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
    f. Maximum fiber stress for design load: 12,000 pounds per square inch.
    g. Maximum deflection due to design load: 1/240 of grating clear span.
    h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
    i. Minimum grating height: 1-1/2 inches.
    j. Manufacturers: The following or equal:
        1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.
3. Aluminum grating planks:
    a. Materials: Meet requirements previously specified for aluminum grating.
    b. Fabrication:
        1) Meet requirements previously specified for aluminum grating.
    c. Have unpunched surface with cross hatched anti-skid surface.
    d. Minimum weight of 3-1/4 pounds per square foot.
    e. Provide 1 inch diameter hole with smooth edges at each end for each plank.
    f. Furnish planks in 2 foot widths.
    g. Manufacturers: The following or equal:
        1) Harsco Industrial IKG, Heavy Duty Aluminum Plank Grating HD-P.
    h. Planks shall not lock with adjacent planks allowing the removal of individual planks without disturbing the adjacent planks.
4. Steel gratings:
    a. Hot-dip galvanized in accordance with ASTM A123.
    b. Bar size and spacing: As determined by the manufacturer to support design load.
    c. Design live load: A minimum of 100 pounds per square foot uniform live load on the entire area of the grating area, but not less than the live load indicated on the Drawings for the area where the grating is located.
    d. Maximum fiber stress for design load: 18,000 pounds per square inch.
    e. Maximum deflection under design load: 1/240 of grating clear span.
    f. Bar spacing: Maximum of 1-1/8 inches clear between bars.
    g. Manufacturers: The following or equal:
        1) Harsco Industrial IKG, IKG Weldforged.
5. Heavy-duty steel grating:
    a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
    b. Hot-dip galvanized after fabrication in accordance with ASTM A123.
    c. Manufacturers: One of the following or equal:
        1) Reliance Steel Products Co., Heavy-Duty Steel Grating.
        2) Seidelhuber Metal Products, Inc., equivalent product.

I. Metal tread plate:
   1. Plate having a raised figured pattern on 1 surface to provide improved traction.

J. Preformed channel pipe supports:
   1. Preformed channel pipe supports for pipe supports and other applications are specified in Section 15062 - Preformed Channel Pipe Support System.

K. Stairs:
   1. Aluminum stairs:
      a. Stringers: 6061-T6 aluminum alloy.
      b. Stair treads:
         1) Aluminum of same type specified under Aluminum Grating.
         2) Of sizes indicated on the Drawings, and 1-3/4 inch minimum depth with cast abrasive type safety nosings.
      c. Handrails and guardrails: Aluminum pipe specified under Aluminum Handrails and Guardrails (Nonwelded Pipe).
      d. Fasteners: Type 304 or Type 316 stainless steel.
   2. Steel stairs:
      a. Ships ladders shall conform to local, State, and OSHA as minimum.
      b. Stringers: Structural steel channels or plates.
      c. Treads: Open type attached to stringers with support angles and clips.
         Manufacturers: One of the following or equal:
         1) Harsco Industrial IKG, "Welded Tread" with Algrip® nosing.
      d. Railings: Steel pipe, sized as indicated on the Drawings.
      e. Anchors: Welded or bolted brackets designed for support and anchorage at top and bottom.
      f. Finish: Prime paint finish for interior locations.

L. Miscellaneous aluminum:
   1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
   2. Do not weld or flame cut.

M. Miscellaneous cast iron:
   1. General:
      a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
      b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
      c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.

N. Miscellaneous stainless steel:
   1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
      a. Fabricate and install in accordance with the best practices of the trade.
   2. Cleaning and passivation:
      a. Following shop fabrication of stainless steel members, clean and passivate fabrications.

b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
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 descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping.
    1) Passivation by citric acid treatment is not allowed.
        a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
    2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
    3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
e. After cleaning, inspect 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 jobsite.

O. Miscellaneous structural steel:
1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
    a. Fabricate and install in accordance with the best practices of the trade.

P. Isolating sleeves and washers:
1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Verification of conditions:
1. Examine work in place to verify that it is satisfactory to receive the work of this Section.
2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

### 3.02 INSTALLATION

A. General:
1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.

2. Interface between materials:
    a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
        1) Make application so that the isolating or protective barrier is not visible in the completed construction.
        2) Isolating sleeves and washers: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
    b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces as specified in Section 09960 - High Performance Coatings.
    c. Aluminum in contact with concrete or masonry.

B. Aluminum stair nosing:
    1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
    2. Omit stair nosings where concrete is submerged.
    3. Cast stair nosings in fresh concrete, flush with tread and riser faces. Install nosing in center of step.

C. Cast iron stop plank grooves:
    1. Recess stop plank grooves with cast iron surfaces of groove set flush with concrete surface.

D. Handrails and guardrails:
    1. General:
        a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
        b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint gap.
        c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
        d. Space attachment brackets as indicated in the manufacturer's instructions.
    2. Aluminum pipe handrails and guardrails:
        a. During construction, keep exterior surfaces of handrails and guardrails covered with minimum 0.4 millimeters of heat shrink polyethylene film.
        b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
        c. Discontinue handrails and guardrails at lighting fixtures.
        d. Provide 1/8-inch diameter weep hole at base of each post.
        e. Space posts as indicated on the Drawings.
        f. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
        g. Space rails as indicated on the Drawings.
        h. Make adequate provision for expansion and contraction of kick plates and rails.
            1) Make provisions for removable sections where indicated on the Drawings.
        i. Make lower rails a single, unspliced length between posts, or continuous.

j. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
k. Draw up fasteners tight with hand wrench or screwdriver.
l. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
o. Replace damaged or disfigured handrails and guardrails with new.
p. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.

3. Steel pipe handrail and guardrail:
a. Anchor posts into concrete by grouting posts into galvanized steel sleeves embedded in concrete as indicated on the Drawings.
1) Do not cut reinforcing bars in concrete.
2) Where required to fasten guardrail to other construction, fasten as indicated on the Drawings.

E. Ladders:
1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
2. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.
3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
4. Erect rail straight, level, plumb, and true to position indicated on the Drawings:
a. Correct deviations from true line or grade which are visible to the eye.

F. Manhole frames and covers:
1. Installation: As recommended by Manufacturer.

G. Metal gratings:
1. General:
a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
d. Install angle stops at ends of grating.
e. Installed grating shall not slide out of rebate or off support.
f. Weld stops in place, unless otherwise specified or indicated on the Drawings.

g. Top surfaces of grating sections adjacent to each other shall lie in same plane.

2. Aluminum grating:
   a. Aluminum grating: Support on aluminum shelf angles or rebates.
3. Aluminum grating planks:
   a. Support and install planks as specified for aluminum grating.
4. Steel grating:
   a. Support on hot-dip galvanized structural steel shelf angles or rebates.
5. Heavy-duty steel grating:
   a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
   b. Use for roadways, traffic areas, and where indicated on the Drawings.

H. Stairs:
   1. General:
      a. Install guard railings around stair wells as indicated on the Drawings or specified.

I. Stainless Steel:
   1. Welding:
      a. Passivate field-welded surfaces:
         1) Provide cleaning, pickling and passivating as specified in this Section.
         2) Clean using Derustit Stainless Steel Cleaner, or equal.

END OF SECTION

## SECTION 07900

## JOINT SEALANTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Silicone sealant.
   3. Synthetic rubber sealing compound.
   4. Synthetic sponge rubber filler.
   5. 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 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.

## 2.04 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
   1. Sika Corporation, Sikaflex 2c NS or SL
   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.

## 2.05 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:
      a. Presstite, No. 750.3 Ropax Rod Stock.
      b. Rubatex Corp., Rubatex-Cord.

B. 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.

## 2.06 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 09910

# PAINTING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Field applied paints and coatings for normal exposures.
   2. Painting Accessories.

### 1.02 DEFINITIONS

A. Paints: Manufacturer's best ready-mixed coatings, except when field catalyzed, with fully ground pigments having soft paste consistency and capable of being readily and uniformly dispersed to complete homogeneous mixture, having good flowing and brushing properties, and capable of drying or curing free of streaks or sags.

B. Volatile Organic Compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon.

### 1.03 SUBMITTALS

A. General: Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings: Include schedule of where and for what use coating materials are proposed in accordance with requirements for Product Data.

C. Product data: Include description of physical properties of coatings including solids content and ingredient analysis, VOC content, temperature resistance, typical exposures and limitations, and manufacturer's standard color chips.

D. Samples: Include 8-inch square drawdowns or brush-outs of topcoat finish when requested. Identify each sample as to finish, formula, color name and number and sheen name and gloss units.

E. Manufacturer's instructions: Submit in accordance with requirements for Product Data. Include:
   1. Special requirements for transportation and storage.
   2. Mixing instructions.
   3. Shelf life.
   4. Pot life of material.
   5. Precautions for applications free of defects.
   6. Surface preparation.
   7. Method of application.
   8. Recommended number of coats.
   9. Recommended thickness of each coat.
   10. Recommended total thickness.

11. Drying time of each coat, including prime coat.
12. Required prime coat.
13. Compatible and non-compatible prime coats.
14. Recommended thinners, when recommended.
15. Limits of ambient conditions during and after application.
16. Time allowed between coats.
17. Required protection from sun, wind and other conditions.
18. Touch-up requirements and limitations.

## 1.04 QUALITY ASSURANCE

A. Products: First line or best grade.

B. Materials for each paint system: By single manufacturer.

C. Applicator qualifications: Applicator of products similar to specified products with minimum 3 years of experience.

D. Regulatory requirements: Comply with by using paints that do not exceed governing agency's VOC limits or do not contain lead.

E. Field samples:
1. Paint 1 complete surface of each color scheme to show colors, finish texture, materials, and workmanship.
2. Obtain approval before painting other surfaces.

## 1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01600 - Product Requirements.

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

C. Deliver containers with labels identifying:
1. Manufacturer's name.
2. Brand name.
3. Product type.
4. Batch number.
5. Date of manufacturer.
6. Expiration date or shelf life.
7. Color.
8. Mixing and reducing instructions.

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

E. Take precautions to prevent fire and spontaneous combustion.

## 1.06 ENVIRONMENTAL CONDITIONS

A. Surface moisture contents: Do not paint surfaces that exceed manufacturer specified moisture contents, or when not specified by the manufacturer, the following moisture contents:
   1. Plaster and gypsum wallboard: 12 percent.
   2. Masonry, concrete and concrete block: 12 percent.
   3. Interior located wood: 15 percent.
   4. Concrete floors: 7 percent.

B. Do not paint or coat:
   1. Under dusty conditions.
   2. When light on surfaces measures less than 15 foot-candles.
   3. When ambient or surface temperature is less than 50 degrees Fahrenheit or unless manufacturer allow a lower temperature.
   4. When relative humidity is higher than 85 percent, unless manufacturer allows a higher relative humidity.
   5. When surface temperature is less than 5 degrees Fahrenheit above dew point.
   6. When surface temperature exceeds the manufacturer's recommendation.
   7. When ambient temperature exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
   8. Apply clear finishes at minimum 65 degrees Fahrenheit.

C. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.

D. Provide adequate continuous ventilation and sufficient heating facilities to maintain minimum 50 degrees Fahrenheit for 24 hours before, during and 48 hours after application of finishes.

## 1.07 PROTECTION

A. Protect adjacent surfaces from paint and damage. Repair damage resulting from inadequate or unsuitable protection.

B. Furnish sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being painted and in particular, surfaces within storage and preparation area.

C. Place cotton waste, cloths, and material that may constitute fire hazard in closed metal containers and remove daily from site.

D. Remove electrical plates, surface hardware, fittings and fastenings, prior to painting operations.
   1. Carefully store, clean and replace on completion of painting in each area.
   2. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finish.

## 1.08 EXTRA MATERIALS

A. Extra materials: Deliver as specified in Section 01770 - Closeout Procedures. Include minimum 1 gallon of each type and color of coating applied:
   1. When manufacturer packages material in gallon cans, deliver unopened labeled cans as comes from factory.
   2. When manufacturer does not package material in gallon cans, deliver material in new gallon containers, properly sealed and identified with typed labels indicating brand, type, and color.

# PART 2 PRODUCTS

## 2.01 MANUFACTURERS

A. Paints: One of the following or equal:
   1. Carboline: Carboline.
   2. PPG Paints/PMC.
   3. Rustoleum: Rustoleum Corp.
   4. S/W: Sherwin-Williams Co.
   5. Tnemec: Tnemec Co.

B. Submit requests for substitutions as specified in Section 01600 - Product Requirements:
   1. Include certified ingredient analyses.
   2. Provide colors that match specified colors.

## 2.02 PRETREATMENT, PRIMERS, AND PRIMER-SEALERS

A. Aluminum primer:
   1. Manufacturers: One of following or equal:
      a. Carboline Co.: Carbocrylic 120.
      b. PPG: Pitt-Tech® Plus 4020 PF Interior/Exterior Primer/Finish, 4020PF.
      c. Sherwin-Williams Co.: DTM Wash Primer.

B. Concrete masonry filler/primer:
   1. Manufacturers: One of following or equal:
      a. Carboline Co.: Sanitile 100.
      b. PPG: Perma-Crete® Interior/Exterior Block & Masonry Surfacer/Filler, 4-100XI.
      c. Sherwin-Williams Co.: HD Block Filler, B42W46.
      d. Tnemec:
         1) Series 130, Envirofill.
         2) Series 180, Tneme-crete.

C. Concrete, porous, filler/primer:
   1. Manufacturers: One of following or equal:
      a. Carboline Co.: Sanitile 100.
      b. PPG: Perma-Crete® Interior/Exterior Block & Masonry Surfacer/Filler, 4-100XI.
      c. Sherwin-Williams Co.: HD Block Filler, B42W46.

d. Tnemec:
    1) Series 130, Envirofill.
    2) Series 180, Tneme-crete.

D. Concrete, smooth, filler/primer:
    1. Manufacturers: One of following or equal:
        a. Carboline Co.: Sanitile 100.
        b. Carboline Co.: Carbocrylic 120.
        c. PPG:
            1) Perma-Crete® Interior/Exterior Block & Masonry Surfacer/Filler, 4-100XI.
            2) Seal Grip® Hydrosealer Exterior Bonding Primer/Sealer, 17-6001.
        d. Sherwin-Williams Co.:
            1) HD Block Filler, B42W46.
            2) Epoxy Masonry Tilt Primer White B42WW49.
        e. Tnemec: Series 180, Tneme-Crete.

E. Ferrous metal primer:
    1. Manufacturers: One of following or equal:
        a. Carboline Co.: Carboguard 890.
        b. PPG: PITT-GUARD® Rapid-Coat Direct-to-Rust Epoxy Mastic Coating, 95-245 Series.
        c. Sherwin-Williams Co.: Macropoxy 646.
        d. Tnemec: Series 104.

F. Galvanized metal surface pretreatment materials:
    1. Manufacturers: One of following or equal:
        a. Carboline Co.: Surface Cleaner 3.
        b. PPG: Duraprep® Concentrated Degreaser, Prep125.

G. Galvanized metal surface primer:
    1. Manufacturers: One of following or equal:
        a. Carboline Co.: Carboguard 890.
        b. PPG: PITT-GUARD® Rapid-Coat Direct-to-Rust Epoxy Mastic Coating, 95-245 Series Sherwin-Williams Co.: Macropoxy 646.
        c. Tnemec: Series 104.

## 2.03 PAINTS, INTERIOR EXPOSURE

A. Latex, flat:
    1. Manufacturers: One of following or equal:
        a. Carboline Co.: Carbocrylic 3359 flat.
        b. PPG:
            1) Speedhide® Zero Interior Flat, 6-5110 Series.
            2) Ultralast Interior Matte, 13-210 Series.
        c. Sherwin-Williams Co.: Promar 200, B30W200.

B. Latex, semi-gloss:
    1. Manufacturers: One of following or equal:
        a. Carboline Co.: Carbocrylic 3359.

b. PPG:
1) Speedhide® Zero Interior Semi-Gloss, 6-5510 Series.
2) Copper Armor Interior Latex Paint + Primer Semi-Gloss, 29-1510.
c. Sherwin-Williams Co.: Promar 200, B77W3402D.

C. Acrylic, semi-gloss:
1. Manufacturers: One of following or equal:
a. Carboline Co.: Carbocrylic 3359.
b. PPG:
1) Speedhide® Zero Interior Semi-Gloss, 6-5510 Series.
2) Copper Armor Interior Latex Paint + Primer Semi-Gloss, 29-1510.
c. Sherwin-Williams Co.: Promar 200, B77W3402D.
d. Tnemec: Series 1029, Enduratone.

## 2.04 PAINTS, EXTERIOR EXPOSURE

A. Latex, flat:
1. Manufacturers: One of following or equal:
a. Carboline Co.: Carbocrylic 3359 flat.
b. PPG:
1) Speedhide® Exterior Flat, 6-6510XI.
c. Sherwin-Williams Co.: A-100, Flat Exterior Latex A6-100.
d. Tnemec: 1028 Enduratone.

B. Acrylic latex, semi-gloss:
1. Manufacturers: One of following or equal:
a. Carboline Co.: Carbocrylic 3359 flat.
b. PPG:
1) Speedhide® Exterior Semi-Gloss, 6-901XI.Sherwin-Williams Co.: A-100, Flat Exterior Latex A6-100.
c. Tnemec: 1028 Enduratone.

# PART 3 EXECUTION

## 3.01 INSPECTION

A. Thoroughly examine surfaces scheduled to be painted before starting work.

B. Start painting when unsatisfactory conditions have been corrected.

## 3.02 SURFACE PREPARATION

A. Prepare surfaces in accordance with paint manufacturer's instructions or when none, the following:
1. Aluminum:
a. Remove surface contamination by steam, high-pressure water, or degreasers.

b. Abrade surface by abrasive blasting, power tool cleaning or hand tool cleaning.
c. Apply etching primer.

2. Reinforced concrete panels:
   a. Remove dirt, powdery residue, and foreign matter.
   b. Paint immediately; both sides when applicable.
3. Canvas and cotton insulation coverings: Remove dirt, grease, and oil.
4. Concrete floors:
   a. Remove contamination, abrasive blast or acid etch and rinse with clear water.
   b. Ensure required acid-alkali balance is achieved. Allow to dry thoroughly.
5. Copper for paint finish:
   a. Remove contamination by steam, high-pressure water, or degreasers.
   b. Abrade surface by abrasive blasting, power tool cleaning or hand tool cleaning.
   c. Apply vinyl etch primer.
6. Copper for oxidized finish:
   a. Remove contamination.
   b. Apply oxidizing solution of copper acetate and ammonium chloride in acetic acid.
   c. Rub on repeatedly for correct effect.
   d. Once attained rinse surfaces well with clear water and allow to dry.
7. Gypsum wallboard:
   a. Remove contamination and prime to show defects.
   b. Repair and prime defects.
8. Galvanized surfaces:
   a. Remove surface contamination and oils and wash with degreasers.
   b. Apply coat of etching type primer.
9. Zinc coated surfaces: Remove surface contamination and oils and prepare for priming in accordance with metal manufacturer's recommendations.
10. Concrete and concrete masonry:
    a. Remove dirt, loose mortar, scale, powder and other foreign matter.
    b. Remove oil and grease with solution of tri-sodium phosphate.
    c. Remove stains caused by weathering of corroding metals with solution of sodium metasilicate.
    d. Rinse well and allow to thoroughly dry.
    e. Spot prime exposed metal with alkyd primer.
11. Plaster:
    a. Fill hairline cracks, small holes and imperfections with patching plaster.
    b. Smooth off to match adjacent surfaces.
    c. Wash and neutralize high alkali surfaces where they occur.
12. Unprimed steel and iron: Remove grease, rust, scale, dirt and dust by wire brushing, sandblasting or other necessary method.
13. Shop primed steel:
    a. Sand and scrape to remove loose primer and rust.
    b. Feather out edges to make touch-up patches inconspicuous.
    c. Clean surfaces.
    d. Prime bare steel surfaces.
14. Wood and millwork:
    a. Sandpaper to smooth even surface.
    b. Wipe off dust and grit prior to priming.

c. Spot coat knots, pitch streaks, and sappy sections with sealer.
d. Fill nail holes and cracks after primer has dried and sand between coats.

15. Exterior wood siding:
    a. Remove dust, grit, and foreign matter.
    b. Seal knots, pitch streak, and sappy sections.
    c. Fill nail holes with exterior caulking compound after prime coat has been applied.
16. Mildew:
    a. Remove by scrubbing with solution of tri-sodium phosphate and chlorine bleach.
    b. Rinse with clean water and allow surface to dry completely.
17. Glue laminated woods:
    a. Remove grease and dirt.
    b. Wash down surfaces with degreasers.

## 3.03 APPLICATION

A. Apply each coat at proper consistency.

B. Tint each coat of paint slightly darker than preceding coat.

C. Sand lightly between coats to achieve required finish.

D. Do not apply finishes on surfaces that are not sufficiently dry.

E. Allow each coat of finish to dry before following coat is applied, unless directed otherwise by manufacturer.

F. Where clear finishes are required ensure tint fillers match wood.
1. Work fillers well into grain before set.
2. Wipe excess from surface.

G. Backprime exterior woodwork, which is to receive paint finish, with exterior primer paint.

H. Backprime interior woodwork, which is to receive paint or enamel finish, with enamel undercoat paint.

I. Backprime interior and exterior woodwork, which is to receive stain or varnish finish, with gloss varnish reduced 25 percent with mineral spirits.

J. Prime top and bottom edges of wood and metal doors with enamel undercoat when they are to be painted.

K. Prime top and bottom edges of wood doors with gloss varnish when they are to receive stain or clear finish.

## 3.04 MECHANICAL AND ELECTRICAL EQUIPMENT

A. Identify equipment, ducting, piping, and conduit in accordance with Related Sections.

B. Remove grilles, covers, and access panels for mechanical and electrical system from location and paint separately.

C. Finish paint primed equipment with color selected by the Engineer.

D. Prime and paint insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are plated or covered with prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when painted over or spattered.

F. Paint interior surfaces of air ducts, convector, and baseboard heating cabinets that are visible through grilles and louvers with 1 coat of flat black paint, to limit of sight line.

G. Paint dampers exposed immediately behind louvers, grilles, convector, and baseboard cabinets to match face panels.

H. Paint exposed conduit and electrical equipment occurring in finished areas with color and texture to match adjacent surfaces.

I. Paint both sides and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

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

## 3.05 SURFACES NOT REQUIRING FINISHING

A. Stainless steel, brass, bronze, copper, Monel®, chromium, anodized aluminum: Specially finished articles such as porcelain enamel, plastic coated fabrics, and baked enamel.

B. Finished products such as ceramic tile, windows, glass, brick, resilient flooring, acoustical tiles, board and metal tees; other architectural features, such as finish hardware, furnished in aluminum, bronze or plated ferrous metal, prefinished panels, or other items that are installed prefinished.

C. Items completely finished at factory, such as preformed metal roof and wall panels, aluminum frames, toilet compartments, sound control panels, acoustical tiles, shower compartments, folding partition, and flagpole.

## 3.06 CLEANING

A. As work proceeds and upon completion, promptly remove paint where spilled, splashed, or spattered.

B. During progress of work, keep premises free from unnecessary accumulation of tools, equipment, surplus materials, and debris.

C. Upon completion of work, leave premises neat and clean.

## 3.07 INTERIOR PAINT SCHEDULE

A. Concrete Masonry: 2 Coats of following finish paints over block filler:
   1. Latex, Semi-Gloss: Walls.

B. Gypsum Board: 2 Coats of following finish paints:
   1. Latex, Semi-Gloss:
      a. Walls and partitions.

C. Metal, galvanized: 2 coats of following finish paints over specified primer:
   1. Acrylic, semi-gloss:
      a. Surfaces not scheduled otherwise.

D. Metal, interior doors and frames, galvanized: 2 coats of following finish paints over specified primer:
   1. Latex, semi-gloss:
      a. Surfaces not scheduled otherwise.

E. Metal, non-galvanized ferrous: 2 coats of following finish paints over specified primer:
   1. Acrylic, semi-gloss:
      a. Surfaces not scheduled otherwise.

F. Metal, interior doors and frames, non-galvanized ferrous: 2 coats of following finish paints over specified primer:
   1. Acrylic, semi-gloss:
      a. Surfaces not scheduled otherwise.

## 3.08 EXTERIOR PAINT SCHEDULE

A. Concrete masonry: 2 coats of following finish paints over specified block filler:
   1. Latex, flat:
      a. Accent band on building exterior.

END OF SECTION

## SECTION 09960

## HIGH-PERFORMANCE COATINGS

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes: Field-applied coatings.

## 1.02 REFERENCES

A. ASTM International (ASTM):
   1. D 16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
   2. D 4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

B. International Concrete Repair Institute (ICRI):
   1. Guideline 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

C. NACE International (NACE):
   1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
   2. SP0188 - Discontinuity (Holiday) Testing of Protective Coatings.

D. National Association of Pipe Fabricators (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Society for Protective Coatings (SSPC):
   1. SP COM - Surface Preparation Commentary for Steel and Concrete Substrates.
   2. SP 1 - Solvent Cleaning.
   3. SP 2 - Hand Tool Cleaning.
   4. SP 3 - Power Tool Cleaning.
   5. SP 5 - White Metal Blast Cleaning.
   6. SP 6 - Commercial Blast Cleaning.
   7. SP 7 - Brush-Off Blast Cleaning.
   8. SP 10 - Near-White Blast Cleaning.
   9. SP 13 - Surface Preparation of Concrete.

G. United States Environmental Protection Agency (EPA):
   1. Method 24 - Surface Coatings.

## 1.03 DEFINITIONS

A. Submerged metal: Steel or iron surfaces below tops of channel or structure walls that will contain water even when above expected water level.

B. Submerged concrete and masonry surfaces: Surfaces that are or will be:
   1. Underwater.
   2. In structures that normally contain water.
   3. Below tops of walls of water-containing structures.

C. Exposed surface: Any metal or concrete surface, indoors or outdoors, that is exposed to view.

D. Dry film thickness (DFT): Thickness of fully cured coating, measured in mils.

E. Volatile organic compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon, as determined by EPA Method 24.

F. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.

G. Where SSPC surface preparation standards are specified or implied for ductile iron pipe or fittings, the equivalent NAPF surface preparation standard shall be substituted for the SSPC standard.

## 1.04 PERFORMANCE REQUIREMENTS

A. Coating materials shall be especially adapted for use in wastewater treatment plants.

B. Coating materials used in contact with potable water supply systems shall be certified to NSF 61.

## 1.05 SUBMITTALS

A. General: Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.

C. Product data: Include description of physical properties of coatings including solids content and ingredient analysis, VOC content, temperature resistance, typical exposures and limitations, and manufacturer's standard color chips:
   1. Regulatory requirements: Submit data concerning the following:
      a. VOC limitations.
      b. Coatings containing lead compounds and polychlorinated biphenyls.
      c. Abrasives and abrasive blast cleaning techniques, and disposal.
      d. NSF certification of coatings for use in potable water supply systems.

D. Samples: Include 8-inch square drawdowns or brush-outs of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.

E. Certificates: Submit in accordance with requirements for Product Data.

F. Manufacturer's instructions: Include the following:
   1. Special requirements for transportation and storage.
   2. Mixing instructions.
   3. Shelf life.
   4. Pot life of material.
   5. Precautions for applications free of defects.
   6. Surface preparation.
   7. Method of application.
   8. Recommended number of coats.
   9. Recommended DFT of each coat.
   10. Recommended total DFT.
   11. Drying time of each coat, including prime coat.
   12. Required prime coat.
   13. Compatible and non-compatible prime coats.
   14. Recommended thinners, when recommended.
   15. Limits of ambient conditions during and after application.
   16. Time allowed between coats (minimum and maximum).
   17. Required protection from sun, wind, and other conditions.
   18. Touch-up requirements and limitations.
   19. Minimum adhesion of each system submitted in accordance with ASTM D4541.

G. Manufacturer's Representative’s Field Reports.

H. Operations and Maintenance Data: Submit as specified in Section 01770 - Closeout Procedures.
   1. Reports on visits to project site to view and approve surface preparation of structures to be coated.
   2. Reports on visits to project site to observe and approve coating application procedures.
   3. Reports on visits to coating plants to observe and approve surface preparation and coating application on items that are “shop coated.”

I. Quality Assurance Submittals:
   1. Quality assurance plan.
   2. Qualifications of coating applicator including List of Similar Projects.

J. Certifications:
   1. Submit notarized certificate that:
      a. All paints and coatings to be used on this project comply with current federal, state, and local VOC regulations.

## 1.06 QUALITY ASSURANCE

A. Applicator 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 2 years.
   2. Manufacturer-approved applicator when manufacturer has approved applicator program.
   3. Approved and licensed by polymorphic polyester resin manufacturer to apply polymorphic polyester resin coating system.
   4. Approved and licensed by elastomeric polyurethane (100-percent solids) manufacturer to apply 100-percent solids elastomeric polyurethane system.
   5. Applicator of off-site application of coal-tar epoxy shall have successfully applied coal-tar epoxy on similar surfaces in material, size, and complexity as on the Project.

B. Regulatory requirements: Comply with governing agencies regulations by using coatings that do not exceed permissible VOC limits and do not contain lead:
   1. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

C. Certification: Certify that applicable pigments are resistant to discoloration or deterioration when exposed to hydrogen sulfide and other sewage gases and product data designates coating as suitable for wastewater service.

D. Field samples:
   1. Prepare and coat a minimum 100-square-foot area between corners or limits such as control or construction joints of each system.
   2. Approved field sample may be part of the Work.
   3. Obtain approval before painting other surfaces.

E. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.

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

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

## 1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01600 - Product Requirements.

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

C. Deliver new unopened containers with labels identifying the manufacturer's name, brand name, product type, batch number, date of manufacturer, expiration date or shelf life, color, and mixing and reducing instructions.
   1. Do not deliver materials aged more than 12 months from manufacturing date.

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

E. Take precautions to prevent fire and spontaneous combustion.

## 1.08 PROJECT CONDITIONS

A. Surface moisture contents: Do not coat surfaces that exceed manufacturer-specified moisture contents, or when not specified by the manufacturer, with the following moisture contents:
   1. Plaster and gypsum wallboard: 12 percent.
   2. Masonry, concrete, and concrete block: 12 percent.
   3. Interior located wood: 15 percent.
   4. Concrete floors: 7 percent.

B. Do not apply coatings:
   1. Under dusty conditions or adverse environmental conditions, unless tenting, covers, or other such protection is provided for structures to be coated.
   2. When light on surfaces measures less than 15 foot-candles.
   3. When ambient or surface temperature is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
   4. When relative humidity is higher than 85 percent.
   5. When surface temperature is less than 5 degrees Fahrenheit above dew point.
   6. When surface temperature exceeds the manufacturer's recommendation.
   7. When ambient temperature exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
   8. Apply clear finishes at minimum 65 degrees Fahrenheit.

C. Provide fans, heating devices, dehumidifiers, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.

D. Provide adequate continuous ventilation and sufficient heating facilities to maintain minimum 55 degrees Fahrenheit for 24 hours before, during, and 48 hours after application of finishes.

E. Dehumidification and heating for coating of digester interiors, wet wells, and high humidity enclosed spaces:
   1. Provide dehumidification and heating of digester interior spaces in which surface preparation, coating application, or curing is in progress according to the following schedule:
      a. October 1 to April 30: Provide continuous dehumidification and heating as required to maintain the tanks within environmental ranges as specified in this Section and as recommended by the coating material manufacturer.

For the purposes of this Section, “continuous” is defined as 24 hours per day and 7 days per week.

b. May 1 to September 30: Provide temporary dehumidification and heating as may be required to maintain the tanks within the specified environmental ranges in the event of adverse weather or other temporary condition. At Contractor’s option and at his sole expense, Contractor may suspend work until such time as acceptable environmental conditions are restored, in lieu of temporary dehumidification and heating. Repair or replace any coating or surface preparation damaged by suspension of work, at Contractor’s sole expense.

2. Equipment requirements:
   a. Capacity: Provide dehumidification, heating, and air circulation equipment with minimum capacity to perform the following:
      1) Maintain the dew point of the air in the tanks at a temperature at least 5 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is underway.
      2) Reduce dew point temperature of the air in the tanks by at least 10 degrees Fahrenheit in 20 minutes.
      3) Maintain air temperature in the tanks at 60 degrees Fahrenheit minimum.
   b. Systems:
      1) Site electrical power: available for Contractor’s use.
      2) Dehumidification: Provide desiccant or refrigeration drying. Desiccant types shall have a rotary desiccant wheel capable of continuous operation. No liquid, granular, or loose lithium chloride drying systems will be allowed.
      3) Heating: Electric, indirect combustion, or steam coil methods may be used. Direct-fired combustion heaters will not be allowed during abrasive blasting, coating application, or coating cure time.
3. Design and submittals:
   a. Contractor shall prepare dehumidification and heating plan for this project, including all equipment and operating procedures.
   b. Suppliers of services and equipment shall have not less than 3 years' experience in similar applications.
      1) Supplier: The following or equal:
         a) Cargocaire Corporation (Munters) or equal.
   c. Submit dehumidification and heating plan for Engineer’s review.
4. Monitoring and performance:
   a. Measure and record relative humidity and temperature of air, and structure temperature twice daily (beginning and end of work shifts) to verify that proper humidity and temperature levels are achieved inside the work area after the dehumidification equipment is installed and operational. Test results shall be made available to the Engineer upon request.
   b. Interior space of the working area and tank(s) shall be sealed, and a slight positive pressure maintained as recommended by the supplier of the dehumidification equipment.

c. The filtration system used to remove dust from the air shall be designed so that it does not interfere with the dehumidification equipment's ability to control the dew point and relative humidity inside the reservoir.
    1) The air from the tank, working area, or dust filtration equipment shall not be recirculated through the dehumidifier during coating application or when solvent vapors are present.

## 1.09 SEQUENCING AND SCHEDULING

A. Sequence and Schedule: As specified in Section 01140 - Work Restrictions.

## 1.10 MAINTENANCE

A. Extra materials: Deliver as specified in Section 01770 - Closeout Procedures. Include minimum 1 gallon of each type and color of coating applied:
    1. When manufacturer packages material in gallon cans, deliver unopened labeled cans as comes from factory.
    2. When manufacturer does not package material in gallon cans, deliver material in new gallon containers, properly sealed and identified with typed labels indicating brand, type, and color.

# PART 2 PRODUCTS

## 2.01 MANUFACTURERS

A. Special coatings: One of the following or equal:
    1. Carboline: Carboline, St. Louis, MO.
    2. Ceilcote: International Protective Coatings, Berea, OH.
    3. Dampney: The Dampney Company, Everett, MA.
    4. Devoe: International Protective Coatings, Louisville, KY.
    5. Dudick: Dudick, Inc., Streetsboro, OH.
    6. GET: Global Eco Technologies, Pittsburg, CA.
    7. Henkel: Henkel North America, Madison Heights, MI.
    8. IET: Integrated Environmental Technologies, Santa Barbara, CA.
    9. PPC: Polymorphic Polymers Corp., North Miami, FL.
    10. PPG Amercoat: PPG Protective & Marine Coatings, Brea, CA.
    11. Rustoleum: Rustoleum Corp., Somerset, NJ.
    12. Sanchem: Sanchem, Chicago, IL.
    13. Superior: Superior Environmental Products, Inc., Addison, TX.
    14. S-W: Sherwin-Williams Co., Cleveland, OH.
    15. Tnemec: Tnemec Co., Kansas City, MO.
    16. Wasser: Wasser High Tech Coatings, Kent, WA.
    17. ZRC: ZRC Worldwide Innovative Zinc Technologies, Marshfield, MA.

## 2.02 PREPARATION AND PRETREATMENT MATERIALS

A. Metal pretreatment: As manufactured by one of the following or equal:
    1. Henkel: Galvaprep 5.
    2. International: AWLGrip Alumiprep 33.

B. Surface cleaner and degreaser: As manufactured by one of the following or equal:
   1. Carboline Surface Cleaner No. 3.
   2. Devoe: Devprep 88.
   3. S-W: Clean and Etch.

## 2.03 COATING MATERIALS

A. Alkali-resistant bitumastic: As manufactured by one of the following or equal:
   1. Carboline: Bitumastic No. 50.
   2. S-W: Targuard.
   3. Wasser: MC-Tar.

B. High solids epoxy (immersion service): As manufactured by one of the following or equal:
   1. Carboline: Carboguard 891.
   2. Devoe: Bar Rust 236.
   3. PPG Amercoat 240.
   4. S-W: Tank Clad HS.
   5. Tnemec: HS Epoxy Series 104.

C. High solids epoxy (non-immersion service) not less than 72 percent solids by volume: As manufactured by one of the following or equal:
   1. Carboline: Carboguard 890.
   2. Devoe: Devran 224V.
   3. PPG Amercoat 385.
   4. S-W: Macropoxy 646.
   5. Tnemec: HS Epoxy Series 69.

D. Aliphatic or aliphatic-acrylic polyurethane: As manufactured by one of the following or equal:
   1. Carboline: Carbothane 134 VOC.
   2. Devoe: Devthane 379.
   3. PPG Amercoat 450H.
   4. Non-submerged: S-W High Solids Polyurethane.
   5. Tnemec: Endura-Shield II Series 1095.

E. Polymorphic polyester resin coating system: 2-component, modified styrene based thermoset resin, EPA approved for potable water, with 100 percent solids and maximum 10 grams per liter VOC. As manufactured by one of the following or equal:
   1. IET: IET Prime Coat DS-101, Intermediate Coat DS-301, and Finish Coat DS 401.
   2. PPC: PPC Prime Coat, IC-Filler Coat, and FC-Final Coat.

F. Asphalt varnish: AWWA C 500.

G. Protective coal tar: As manufactured by one of the following or equal:
   1. Carboline: Bitumastic No. 50.
   2. PPG Amercoat: 78HB

H. Coal-tar epoxy substitute: As manufactured by one of the following or equal:
   1. Devoe: Devtar 5A HS.
   2. S-W: Macropoxy 646 Black.

I. Waterborne acrylic emulsion: As manufactured by one of the following or equal:
   1. S-W: DTM Acrylic B66W1.
   2. Tnemec: Tneme-Cryl Series 6.

J. Galvanizing zinc compound: As manufactured by one of the following or equal:
   1. ZRC: Cold Galvanizing Compound.

K. 100 Percent Solids Chemical Resistant Coating: As manufactured by one of the following or equal:
   1. Eduraflex Systems: EF1988
   2. United Coatings: Elastuff 120

## 2.04 MIXES

A. Mix in accordance with manufacturer's instructions.

# PART 3 EXECUTION

## 3.01 GENERAL PROTECTION

A. Protect adjacent surfaces from coatings and damage. Repair damage resulting from inadequate or unsuitable protection.

B. Protect adjacent surfaces not to be coated from spatter and droppings with drop cloths and other coverings:
   1. Mask off surfaces of items not to be coated or remove items from area.

C. Furnish sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

D. Place cotton waste, cloths, and material that may constitute a fire hazard in closed metal containers and remove daily from site.

E. Remove electrical plates, surface hardware, fittings, and fastenings prior to application of coating operations. Carefully store, clean, and replace on completion of coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finish.

## 3.02 GENERAL PREPARATION

A. Prepare surfaces in accordance with coating manufacturer's instructions, unless more stringent requirements are specified in this Section.

B. Protect the following surfaces from abrasive blasting by masking or other means:
   1. Threaded portions of valve and gate stems, grease fittings, and identification plates.

2. Machined surfaces for sliding contact.
3. Surfaces to be assembled against gaskets.
4. Surfaces of shafting on which sprockets are to fit.
5. Surfaces of shafting on which bearings are to fit.
6. Machined surfaces of bronze trim, including slide gates.
7. Cadmium-plated items except cadmium-plated, zinc-plated, or sherardized fasteners used in assembly of equipment requiring abrasive blasting.
8. Galvanized items, unless scheduled to be coated.

C. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by entering sand or dust.

D. Concrete:
1. Allow new concrete to cure for minimum of 28 days before coating.
2. Clean concrete surfaces of dust, mortar, fins, loose concrete particles, form release materials, oil, and grease. Fill voids so that surface is smooth. Prepare concrete surface for coating in accordance with SSPC SP 13. Provide ICRI 310.2 CSP-3 surface profile, or as recommended by coating manufacturer. All concrete surfaces shall be vacuumed clean prior to coating application.

E. Ferrous metal surfaces:
1. Remove grease and oil in accordance with SSPC SP 1.
2. Remove rust, scale, and welding slag and spatter, and prepare surfaces in accordance with appropriate SSPC standard as specified.
3. Abrasive blast surfaces prior to coating.
   a. When abrasive blasted surfaces rust or discolor before coating, abrasive blast surfaces again to remove rust and discoloration.
   b. When metal surfaces are exposed because of coating damage, abrasive blast surfaces and feather in to a smooth transition before touching up.
   c. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC SP 10, unless blasting may damage adjacent surfaces, prohibited, or specified otherwise. Where not possible to abrasive blast, power tool clean surfaces in accordance with SSPC SP 3.
   d. Ferrous metal surfaces to be submerged: Unless specified otherwise, abrasive blast in accordance with SSPC SP 5 to clean and provide roughened surface profile of not less than 2 mils and not more than 4 mils in depth when measured with Elcometer 123, or as recommended by the coating manufacturer.
4. All abrasive blast cleaned surfaces shall be blown down with clean dry air and/or vacuumed.

F. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

G. Sherardized, aluminum, copper, and bronze surfaces: Prepare in accordance with coating manufacturer's instructions.

H. Galvanized surface:
1. Degrease or solvent clean (SSPC SP 1) to remove oily residue.
2. Power tool or hand tool clean or whip abrasive blast.
3. Test surface for contaminants using copper sulfate solution.

4. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded physically, such as bolts, nuts, or preformed channels.

I. Shop-primed metal:
   1. Certify that primers applied to metal surfaces in the shop are compatible with coatings to be applied over such primers in the field.
   2. Remove shop primer from metal to be submerged by abrasive blasting in accordance with SSPC SP 10, unless greater degree of surface preparation is required by coating manufacturer's representative.
   3. Correct abraded, scratched, or otherwise damaged areas of prime coat by sanding or abrasive blasting to bare metal in accordance with SSPC SP 2, SP 3, or SP 6, as directed by the Engineer. When entire shop priming fails or has weathered excessively (more than 25 percent of the item), or when recommended by coating manufacturer's representative, abrasive blast shop prime coat to remove entire coat and prepare surface in accordance with SSPC SP 10.
   4. When incorrect prime coat is applied, remove incorrect prime coat by abrasive blasting in accordance with SSPC SP 10.
   5. When prime coat not authorized by Engineer is applied, remove unauthorized prime coat by abrasive blasting in accordance with SSPC SP 10.
   6. Shop applied bituminous paint or asphalt varnish: Abrasive blast clean shop applied bituminous paint or asphalt varnish from surfaces scheduled to receive non-bituminous coatings.

J. Cadmium-plated, zinc-plated, or sherardized fasteners:
   1. Abrasive blast in the same manner as unprotected metal when used in assembly of equipment designated for abrasive blasting.

K. Abrasive blast components that are to be attached to surfaces that cannot be abrasive blasted before components are attached.

L. Grind sharp edges to approximately 1/16-inch radius before abrasive blast cleaning.

M. Remove and grind smooth all excessive weld material and weld spatter before blast cleaning in accordance with NACE SP0178.

N. Poly vinyl chloride (PVC) and FRP surfaces:
   1. Prepare surfaces to be coated by light sanding (de-gloss) and wipe-down with clean cloths, or by solvent cleaning in strict accordance with coating manufacturer's instructions.

O. Cleaning of previously coated surfaces:
   1. Utilize cleaning agent to remove soluble salts such as chlorides and sulfates from concrete and metal surfaces:
      a. Cleaning agent: Biodegradable non-flammable and containing no VOC.
      b. Manufacturer: The following or equal:
         1) CHLOR*RID International, Inc.
   2. Steam clean and degrease surfaces to be coated to remove oils and grease.
   3. Cleaning of surfaces utilizing the decontamination cleaning agent may be accomplished in conjunction with abrasive blast cleaning, steam cleaning,

high-pressure washing, or hand washing as approved by the coating manufacturer's representative and the Engineer.

4. Test cleaned surfaces in accordance with the cleaning agent manufacturer's instructions to ensure all soluble salts have been removed. Additional cleaning shall be carried out as necessary.
5. Final surface preparation prior to application of new coating system shall be made in strict accordance with coating manufacturer's printed instructions.

## 3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit as specified in Section 15075 - Equipment Identification and Section 16075 - Identification for Electrical Systems.

B. Remove grilles, covers, and access panels for mechanical and electrical system from location and coat separately.

C. Prepare and finish coat primed equipment with color selected by the Engineer.

D. Prepare and prime and coat insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts, and convector and baseboard heating cabinets that are visible through grilles and louvers with 1 coat of flat black paint, to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and electrical equipment occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat both sides and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

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

## 3.04 GENERAL APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Coat metal unless specified otherwise:
   1. Aboveground piping to be coated shall be empty of contents during application of coatings.

C. Verify metal surface preparation immediately before applying coating in accordance with SSPC SP COM.

D. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

E. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

F. Prime shop-primed metal surfaces. Spot prime exposed metal of shop-primed surfaces before applying primer over entire surface.

G. Multiple coats:
   1. Apply minimum number of specified coats.
   2. Apply additional coats when necessary to achieve specified thicknesses.
   3. Apply coats to thicknesses specified, especially at edges and corners.
   4. When multiple coats of same material are specified, tint prime coat and intermediate coats with suitable pigment to distinguish each coat.
   5. Lightly sand and dust surfaces to receive high-gloss finishes, unless instructed otherwise by coating manufacturer.
   6. Dust coatings between coats.

H. Coat surfaces without drops, overspray, dry spray, runs, ridges, waves, holidays, laps, or brush marks.

I. Remove spatter and droppings after completion of coating.

J. Apply coating by brush, roller, trowel, or spray, unless particular method of application is required by coating manufacturer's instructions or these Specifications.

K. Plural component application: Drums shall be premixed each day. All gauges shall be in working order prior to the start of application. Ratio checks shall be completed prior to each application. A spray sample shall be sprayed on plastic sheeting to ensure set time is complete prior to each application. Hardness testing shall be performed after each application.

L. Spray application:
   1. Stripe coat edges, welds, nuts, bolts, and difficult-to-reach areas by brush before beginning spray application, as necessary, to ensure specified coating thickness along edges.
   2. When using spray application, apply coating to thickness not greater than that recommended in coating manufacturer's instructions for spray application.
   3. Use airless spray method, unless air spray method is required by coating manufacturer's instruction or these Specifications.
   4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

M. Drying and recoating:
   1. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of

substrate, coating between coats and within curing time following application of last coat.
2. For submerged service, the Contractor shall provide a letter to the Engineer that the lining system is fully cured and ready to be placed into service.
3. Limit drying time to that required by these Specifications or coating manufacturer's instructions.
4. Do not allow excessive drying time or exposure, which may impair bond between coats.
5. Recoat epoxies within time limits recommended by coating manufacturer.
6. When time limits are exceeded, abrasive blast clean and de-gloss clean prior to applying another coat.
7. When limitation on time between abrasive blasting and coating cannot be met before attachment of components to surfaces that cannot be abrasive blasted, coat components before attachment.
8. Ensure primer and intermediate coats of coating are unscarred and completely integral at time of application of each succeeding coat.
9. Touch-up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
10. Leave no holidays.
11. Sand and feather in to a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so damages are invisible to the naked eye.

N. Concrete:
1. Apply first coat (primer) only when surface temperature of concrete is decreasing in order to eliminate effects of off-gassing on coating.

## 3.05 ALKALI-RESISTANT BITUMASTIC

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements.

B. Application:
1. Apply in accordance with general application requirements and as follows:
a. Apply at least 2 coats, 8 to 14 mils DFT each.

## 3.06 HIGH SOLIDS EPOXY SYSTEM

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements and as follows:
a. Abrasive blast ferrous metal surfaces to be submerged at jobsite in accordance with SSPC SP 5 prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP 10.
b. Abrasive blast non-submerged ferrous metal surfaces at jobsite in accordance with SSPC SP 10, prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP 6.
c. Abrasive blast clean ductile iron surfaces at jobsite in accordance with SSPC SP 7.

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

## 3.07 HIGH SOLIDS EPOXY AND POLYURETHANE COATING SYSTEM

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

B. Application:
   1. Apply coatings in accordance with general application requirements and as follows:
      a. Apply a 3-coat system consisting of:
         1) Primer: 4 to 5 mils DFT high solids epoxy.
         2) Intermediate coat: 4 to 5 mils DFT high solids epoxy.
         3) Topcoat: 2.5 to 3.5 mils DFT aliphatic or aliphatic-acrylic polyurethane topcoat.
   2. Recoat or apply succeeding epoxy coats within 30 days or within time limits recommended by manufacturer, whichever is shorter. Prepare surfaces for recoating in accordance with manufacturer's instructions.

## 3.08 POLYMORPHIC POLYESTER RESIN SYSTEM

A. Preparation:
   1. Prepare surfaces in accordance with general preparation requirements and as follows:
   2. Prepare concrete to obtain clean, open pore with exposed aggregate in accordance with manufacturer's instructions.

3. Prepare ferrous metal surfaces in accordance with SSPC SP 5, with coating manufacturer's recommended anchor pattern.
4. Complete abrasive blast cleaning within 6 hours of applying prime coat. Dew point shall remain 5 degrees above dew point 8 hours after application of coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP 5.
5. When handling steel, wear gloves to prevent hand printing.
6. Adjust pH of concrete to within 5.5 to 8.0 before applying prime coat.

B. Application:
1. Apply coatings in accordance with general application requirements and as follows:
a. Apply minimum DFT system consisting of primer, tie coat and top coat in accordance with manufacturer's instructions as follows:
1) Steel: 35 mils.
2) Concrete: 45 mils.

## 3.09 ASPHALT VARNISH

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements.

B. Application:
1. Apply coatings in accordance with general application requirements and as follows:
a. Apply minimum 2 coats.

## 3.10 COAL-TAR EPOXY SUBSTITUTE

A. Preparation:
1. Prepare surfaces in accordance with general preparation requirements and in accordance with the coating manufacturer's printed instructions.

B. Application:
1. Apply 2 coats at 6 mils to 8 mils each, for a minimum total DFT of 12 mils.

## 3.11 WATERBORNE ACRYLIC EMULSION

A. Preparation:
1. Remove all oil, grease, dirt, and other foreign material by solvent cleaning in accordance with SSPC SP 1.
2. Lightly sand all surfaces and wipe thoroughly with clean cotton cloths before applying coating.

B. Application:
1. Apply 2 or more coats to obtain a minimum DFT of 5.0 mils.

## 3.12 WATER PROOFING

A. Water Proofing Requirements per Section 07130 - Sheet Waterproofing.

## 3.13 100 PERCENT SOLIDS CHEMICAL RESISTANT COATING

A. Preparation:
   1. Prepare surfaces in accordance with part 3.02.D of this section, unless manufacturer's requirements are more stringent.

B. Application:
   1. Coating shall be field applied by a certified applicator. Crack bridging shall be used over expansion joints.
   2. System thickness (total):
      a. 45 mils DFT.

C. Coating:
   1. Primer: Epoxy, 5 mils DFT.
   2. Finish: 100 percent solids coating, 40 mils DFT.

D. Testing:
   1. High voltage spark test (100 volts/mils) to provide a verified pinhole free coating system.

## 3.14 FIELD QUALITY CONTROL

A. Each coat will be inspected. Strip and remove defective coats, prepare surfaces, and recoat. When approved, apply next coat.

B. Control and check DFT and integrity of coatings.

C. Measure DFT with calibrated thickness gauge.

D. DFT on ferrous-based substrates may be checked with Elcometer Type 1 Magnetic Pull-Off Gauge or PosiTector® 6000.

E. Verify coat integrity with low-voltage sponge or high-voltage spark holiday detector, for submerged service, in accordance with NACE SP0188. Allow Engineer to use detector for additional checking.

F. Check wet film thickness before coal-tar epoxy coating cures on concrete or non-ferrous metal substrates.

G. Arrange for services of coating manufacturer's field representative to provide periodic field consultation and inspection services to ensure proper surface preparation of facilities and items to be coated, and to ensure proper application and curing:
   1. Notify Engineer 24 hours in advance of each visit by coating manufacturer's representative.
   2. Provide Engineer with a written report by coating manufacturer's representative within 48 hours following each visit.

## 3.15 SCHEDULE OF ITEMS NOT REQUIRING COATING

A. General: Unless specified otherwise, the following items do not require coating:
   1. Items that have received final coat at factory and are not listed to receive coating in field are still required to receive a final coat of color preference by Owner. See paragraph 3.17.B in this section.
   2. Aluminum, brass, bronze, copper, plastic (except PVC pipe), rubber, stainless steel, chrome, Everdur, or lead.
   3. Buried or encased piping or conduit.
   4. Exterior concrete.
   5. Galvanized steel wall framing, galvanized electrical conduits, galvanized pipe trays, galvanized cable trays, and other galvanized items:
      a. Areas on galvanized items or parts where galvanizing has been damaged during handling or construction shall be repaired as follows:
         1) Clean damaged areas by SSPC SP 1, SP 2, SP 3, or SP 7 as required.
         2) Apply 2 coats of a galvanizing zinc compound in strict accordance with manufacturer's instructions.
   6. Grease fittings.
   7. Fiberglass ducting or tanks in concealed locations.
   8. Steel to be encased in concrete or masonry.

## 3.16 SCHEDULE OF EXISTING SURFACES TO BE COATED IN THE FIELD

A. Concrete:
   1. Sandblast the following structures to remove existing coating:
      a. Exposed concrete of Bioreactors 1 and 2.
      b. Exposed concrete of Clarifiers 1, 2, and 3.
      c. Exposed concrete of Clarifier Splitter Box 1 and 2.

B. Metals:
   1. High solids epoxy as specified in paragraph 3.06 High Solids Epoxy System.
      a. Clarifier mechanism for Clarifier 1.
   2. High solids epoxy and polyurethane coating as specified in Paragraph 3.07 - High Solids Epoxy and Polyurethane Coating System.
      a. Noise control enclosures for Bioreactor 1, and 2 Aerators (4 total).
      b. Roll-up doors and all exterior/interior doors on RAS Building.
      c. Roll-up doors and all exterior/interior doors in Headworks Building.
      d. Roll-up doors and all exterior/interior doors in existing Solids Dewatering Building (Parts Storage Building).
      e. Roll-up doors and all exterior/interior doors in Chemical Phosphorus Building.
      f. All exterior/interior doors of the Main Electrical Building.

## 3.17 SCHEDULE OF NEW SURFACES TO BE COATED IN THE FIELD

A. In general, apply coatings to steel, iron, galvanized surfaces, and wood surfaces unless specified or otherwise indicated on the Drawings. Coat concrete surfaces and anodized aluminum only when specified or indicated on the Drawings.

B. All factory finished mechanical equipment shall receive a final field coat, along with all piping, per Owner's color selection and as specified in Section 15075 - Equipment Identification.

C. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Verify questionable surfaces.

D. Concrete:
   1. High solids epoxy:
      a. Safety markings.
   2. Concrete floor coating:
      a. Concrete sealer on all interior exposed concrete floors as per Section 03300 - Cast-in-Place Concrete.
   3. 100 Percent Solids Chemical Resistant Coating:
      a. Equalization Basin inlet and outlet channels:
         1) Side walls full height and underside of concrete deck.
      b. Equalization Basin walls (Equalization Basins 1, 2, and 3) full height and interior concrete ceiling.
      c. New Anaerobic Zones (3):
         1) The anaerobic zone walls from elevation 6268.00 to top of walls and underside of concrete deck, including beams, covering the anaerobic zones.

E. Metals:
   1. Alkali-resistant bitumastic:
      a. Aluminum surfaces to be placed in contact with wood, concrete, or masonry.
   2. Wax coating:
      a. Sliding faces of sluice and slide gates and threaded portions of gate stems.
   3. High solids epoxy and polyurethane system: Interior and exterior non immersed ferrous metal surfaces including:
      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 including galvanized structural steel and exposed metal decking, or meal decking that will be covered by insulation.
      g. Crane and hoist rails.
      h. Exterior of tanks and other containment vessels.
      i. Mechanical equipment supports, drive units, and accessories.
      j. Pumps not submerged.
      k. Degritters, grit classifiers, frames, supports, and associated equipment.
      l. Other miscellaneous metals.
      m. Grit separation and washer, frames, supports, and associated equipment.

4. High solids epoxy system:
    a. Field priming of ferrous metal surfaces with defective shop-prime coat where no other prime coat is specified; for non-submerged service.
    b. Bell rings, underside of manhole covers and frames.
    c. Sump pumps and grit pumps, including underside of base plates and submerged suction and discharge piping.
    d. Clarifier mechanism.
    e. Exterior of submerged piping and valves other than stainless steel or PVC piping.
    f. Submerged pipe supports and hangers.
    g. Stem guides.
    h. Vertical shaft mixers and aerators below supports.
    i. Other submerged iron and steel metal unless specified otherwise.
    j. Interior surface of suction inlet and volute of submersible influent pumps. Apply coating prior to pump testing.
    k. Submerged piping.
    l. Exterior of influent pumps and influent pump submerged discharge piping.
5. Polymorphic polyester resin system:
    a. Surfaces where indicated on the Drawings following a short cure time.
6. Asphalt varnish:
    a. Underground valve boxes.
7. Protective coal tar:
    a. Underground pipe flanges, excluding pipe, corrugated metal pipe couplings, flexible pipe couplings and miscellaneous underground metals not otherwise specified to receive another protective coating.

F. Fiberglass and PVC pipe surfaces:
1. Waterborne acrylic emulsion.
    a. Exterior of fiberglass ducting and fan housings.
    b. Fiberglass expose to sunlight.
    c. PVC piping exposed to view.
    d. ABS piping as determined by Engineer.

END OF SECTION

## SECTION 15050

## COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

## PART 1 GENERAL

### 1.02 SUMMARY

A. Section includes:
   1. Mechanical equipment requirements for:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation requirements.

### 1.03 REFERENCES

A. American Bearing Manufactures Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Gear Manufacturer's Association (AGMA) Standards.

C. ASTM International (ASTM):
   1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   2. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   4. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   5. F594 - Standard Specification for Stainless Steel Nuts.

D. Hydraulic Institute (HI):
   1. 9.6.8 - Guideline for Dynamics of Pumping Machinery.

E. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

F. International Organization for Standardization (ISO):
   1. 21940 - Mechanical Vibration - Rotor Balancing - Part 1: Introduction.

G. National Electrical Manufacturers Association (NEMA):
   1. MG-1 - Motors and Generators.

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

## 1.04 DEFINITIONS

A. Definitions used in this specification and equipment submittals for terms related to rotor-dynamic pumps shall be in accordance with HI 9.6.8, Appendix A, as clarified below.

B. These definitions shall be applied to equipment other than pumps, unless otherwise specified in technical sections.

C. Rotordynamic Analysis Level:
   1. The level of detail required for rotordynamic analysis is indicated in the technical sections schedules as None (no analysis required), Analysis Level 1, Analysis Level 2, or Analysis Level 3, which correlate to increasing levels of required detailed equipment design analysis. Analysis Levels 1, 2 and 3 are based on HI 9.6.8.
   2. Where these specifications differ from HI the more stringent shall apply.

D. Resonant Frequency:
   1. The frequency of a periodic excitation force that is close to the natural frequencies of an object. Also known as critical frequency, critical speed, or resonant speed.
   2. An undamped resonant frequency within the separation margin is always considered harmful under Level 1 analysis.
   3. A resonant frequency that occurs within a separation margin of 15 percent above or below the operating speed range and has a log decrement greater than +0.3 is considered harmful under Level 2 and Level 3 analysis.

E. Separation margin:
   1. The span of operating speeds within which interference between excitation orders and resonant frequencies indicate the possibility of harmful vibrations.
   2. The separation margin for a specific application extends 15 percent above and 15 percent below the span of operating speed required for the specified performance conditions.

## 1.05 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination.
   1. Show roof penetrations for mechanical equipment on roof drawing submittal and include mechanical equipment information:
      a. Type.
      b. Size.
      c. Location.
      d. Configuration of penetration and the surround.
      e. Weight.
      f. Anchoring and support details.

## 1.06 SUBMITTALS

A. Items in this Section are components of equipment or systems specified in other sections.
   1. Include data for this Section's components with the equipment or system submittal.

# PART 2 PRODUCTS

## 2.01 DESIGN AND PERFORMANCE CRITERIA

A. General:
   1. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries to provide a complete, operable unit.
   2. Manufacturer shall analyze all rubber-bearing vertical-column pumps, and equipment identified as non-reversing in the technical sections for reverse rotation and provide non reversing motor ratchets.
   3. Equipment that prevents reverse rotation shall be capable of both:
      a. Handling 150 percent of the maximum torque at maximum operating speed.
      b. 150 percent of torque that will be generated in reverse direction due to equipment shutoff head as calculated by the manufacturer.
   4. The motor shall be designed to run safely in the reverse direction at up to 140 percent times the reverse runaway speed under shutoff head conditions.

B. Rotordynamic analysis and vibration testing:
   1. Submit information for the Rotordynamic Analysis Level specified for each piece of equipment as shown in the Technical Sections prior to manufacture of the equipment.
   2. Rotordynamic analysis shall be performed on "like-new" and "as-worn" conditions, representing conditions when first installed and conditions when parts wear to the manufacturer's maximum allowable operating tolerances. Conditions assumed for the "as-worn" condition shall be 2 times the "like-new" tolerances unless specified otherwise.
   3. Rotordynamic analysis criteria:
      a. Torsional excitation forcing function magnitudes shall be no less than 1 percent of the maximum transmitted torque at given speed.
      b. Motor mass elastic information in accordance with NEMA MG-1 shall be obtained from the original equipment manufacturer and included in the analysis. Motors shall be precision balanced to ISO 21940 grade G2.5.
      c. Bearings:
         1) At maximum bearing loads an L-10 life of 100,000 hours in accordance with ABMA 9-11 to be proven.
   4. Submit factory and field-testing requirements as specified in the Technical Sections and specified in Section 15958 - Mechanical Equipment Testing after manufacture and installation respectively.
   5. Repair, replace, and modify equipment exhibiting vibration performance that does not meet criteria specified in this Section at no additional cost to Owner. Acceptable remedies include adjustments to equipment component geometry,

materials, energy absorbing couplings, etc. Locking out speed interval(s) within equipment specified operating range is unacceptable.

6. Vibration analysis expert:
   a. Provide vibration analysis expert when specified in the equipment Technical Sections.
      1) The vibration analysis expert must be a third party, unaffiliated with the equipment vendor or Contractor.
   b. The vibration analysis expert, and analysis shall be provided by one of the following or equal:
      1) Mechanical Solutions, Inc. (MSI, New Jersey).
      2) Engineering Dynamics Inc. (EDI, Texas).
   c. The analysis shall be:
      1) Stamped by a registered professional mechanical engineer.
      2) Verified in-situ by the vibration analysis expert including certification that installation conforms to field conditions assumed in the reports.
      3) Verified in-situ by the vibration analysis expert including witness of at least one field vibration test, and certification that vibration measurements corroborate the rotordynamic analysis.
      4) Supplemented with additional field investigation and analysis should conditions during field vibration testing activity indicate non-compliance with these specifications; supplemental field investigation and analysis shall indicate remedies to comply with the specifications and shall be stamped by a registered professional mechanical engineer.
7. Rotordynamic Analysis Level 1:
   a. Before the equipment is released for manufacture it shall be determined that the equipment/motor structures do not have any harmful resonant frequencies in the lateral and torsional modes. Representative analysis results for identical equipment may be submitted.
   b. Calculate rotor lateral and torsional and equipment structural components' lateral frequencies with a spreadsheet calculation or finite element analysis software.
      1) Equipment structure lateral frequency shall include the motor.
      2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
   c. Determine the equipment system components (rotor and structure) resonant frequencies.
   d. An intersection of an equipment component resonant frequency with the 1x run speed excitation order that occurs within separation margin is unacceptable.
8. Rotordynamic Analysis Level 2:
   a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
   b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
      1) Equipment structure lateral frequency shall include the motor.
      2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
      3) The rotational inertia of water within the impeller, in the wet well and inside the equipment structure, e.g., the column of a vertical pump,

shall be included in the calculation at both the high-level and low-level conditions.

c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.

d. Forced damped analysis:

1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.

2) Forced torsional analysis shall include not less than 1 percent of the maximum permitted torque at any given speed. Damping shall be one percent of critical at all shaft elements.

3) The equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:

a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.

b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.

c) Submit documentation of material fatigue limit.

e. Report submittals:

1) Confirmation of compliance with this Section, or detailed exceptions taken.

2) Software used for analysis.

3) Results with interpretation.

4) Preparer's professional engineering stamp and seal.

5) Input data including component properties, materials and connectivity to other components.

6) Schematic diagram of model mode shapes, nodes and elements.

7) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.

8) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.

a) Campbell diagram shall include equipment operating range; excitation lines at 1x, 2x run speed, and vane pass (or equivalent); and critical speeds associated with equipment system components including the rotor, each major equipment structural component and the motor.

9) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.

9. Rotordynamic Analysis Level 3:

a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.

b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
    1) Equipment structure lateral frequency shall include the motor.
    2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
    3) The rotational inertia of water within the impeller, in the wet well and inside the equipment structure, e.g., the column of a vertical pump, shall be included in the calculation at both the high-level and low-level conditions.
c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.
d. Forced damped analysis:
    1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
    2) Forced torsional analysis shall include 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
    3) The equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
        a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
        b) Variable Torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
        c) Submit documentation of material fatigue limit.
e. Report submittals:
    1) Report 1: Executive Summary including:
        a) Confirmation of compliance with this specification section, or detailed exceptions taken.
        b) Software used for analysis.
        c) Results with interpretation.
        d) Preparer's professional engineering stamp and seal.
        e) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
            (1) Campbell diagram shall include equipment operating range; excitation lines at 1x, 2x run speed, vane pass (or equivalent), line- and twice-line frequency, motor-pole frequency, torsional harmonics from reciprocating drivers (including up to 6 times operating speed), control pulse frequencies induced by VFDs (with certification from VFD manufacturer of frequencies up to 24 times motor running speed), any torque harmonic greater than 1 percent of steady torque at primary excitation, and synchronous motor requirements; and critical speeds associated with

equipment system components including the rotor and each major equipment structural component.

f) Report 1 shall not include detailed analysis elements listed for submittal under Report 2 below, submittal of full analysis details in Report 1 is unacceptable.

g) Following submittal of Report 1, submit Report 2: Detailed Analysis including responses to comments made on Report 1: Rotor-dynamic Executive Summary.

2) Report 2: Rotor-dynamic Detailed Analysis including:

a) Input data including component properties, materials and connectivity to other components.

b) Schematic diagram of model mode shapes, nodes and elements.

c) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.

d) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.

e) Synchronous motor information including time-integration study results showing transient peak stresses at startup, shutdown and motor control transient events. Provide tomographic diagrams including root and keyway stress concentration locations and the corresponding speeds that result in reported peak stresses.

## 2.02 POWER TRANSMISSION SYSTEMS

A. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints:

1. Rated for 24 hour-a-day continuous service, or for intermittent service with frequent stops-and-starts, whichever is most severe.
2. Sized with a service factor of 1.5 or greater:
   a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
   b. Apply service factors in accordance with AGMA or as specified in the Technical Sections.

## 2.03 BEARINGS

A. Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.

1. Design lubrication system based on the equipment location to operate in the temperatures as specified in Section 01850 - Design Criteria.
   a. Design lubrication system to safely start after being shut off for 24 hours and operate safely:
      1) Suitable for the outdoor winter temperature as specified in Section 01850 - Design Criteria.

B. Oil-lubricated bearings:

1. Provide either pressure lubricating system or separate oil reservoir splash-type system as specified in the Technical Section.

2. Design oil-lubrication system to safely absorb heat energy generated in bearings when equipment is operating in the following conditions:
    a. With the highest load and the temperature 15 degrees Fahrenheit above the outdoor summer temperature as specified in Section 01850 - Design Criteria.

C. Grease lubricated bearings, except those specified to be factory sealed:
1. Fit with easily accessible grease supply, flush, drain, and relief fittings.
2. Lubrication lines and fittings:
    a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
    b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
    c. Use standard hydraulic-type grease supply fittings:
        1) Manufacturers: One of the following or equal:
            a) Alemite.
            b) Zerk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

## 2.04 BELT DRIVES

A. Sheaves:
1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
4. Key bushings to drive shaft.

B. Belts:
1. Anti-static type when explosion-proof equipment or environment is specified.
2. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
    a. Where 2 or more belts are involved, furnish matched sets.
    b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
    c. Package in boxes labeled with identification of contents.

C. Manufacturers: One of the following or equal:
1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
2. T. B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

## 2.05 FLANGED PIPING CONNECTIONS

A. Unless otherwise in the Technical Sections or indicated on the Drawings, provide flat face flanges.

## 2.06 ASSEMBLY FASTENERS

A. General service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM F593, Alloy Group 2.
   2. Nuts: In accordance with ASTM F594, Alloy Group 2.
   3. Washers: Alloy group matching bolts and nuts.

B. High-temperature service or high-pressure service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM A193, Grade B8M, Class 1, heavy hex.
   2. Nuts: In accordance with ASTM A194, Grade 8, heavy hex.
   3. Washers: Alloy group matching bolts and nuts.

C. Low-temperature service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM A320, Grade B8M, Class 1, heavy hex.
   2. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
   3. Washers: Alloy group matching bolts and nuts.

## 2.07 GUARDS AT HIGH-TEMPERATURE SURFACES

A. Exposed surfaces having an external surface temperature of 120 degrees Fahrenheit or higher and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps or fixed ladders.

B. Cover with a thermal insulating material unless otherwise guarded against contact.
   1. Insulation thickness such that the insulation exterior temperature is below 120 degrees Fahrenheit.
   2. Insulation Type 3 and cover Type 5 as specified in Section 15082 - Piping Insulation.

## 2.08 GUARDS AT MOVING COMPONENTS

A. Provide guards on rotating components that are within 7.5 vertical feet of an operating floor or platform.

B. Allow visual inspection of moving parts without removal.

C. Allow access to lubrication fittings.

D. Easily removable for maintenance.

E. Prevent entrance of rain or dripping water for outdoor locations.

F. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.

G. Materials:
   1. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
   2. Fasteners: Type 316 stainless steel.

## 2.09 SHOP FINISHES

A. Manufacturer's standard primer and finish coatings.
   1. Primer only if field coatings are to be applied.

## 2.10 GEAR MOTORS

A. Parallel shaft drives: Helical gearing.

B. Right-angle drives: Worm gearing.

C. Manufacturers: One of the following or equal:
   1. Baldor Electric Company.
   2. Bodine Electric Company.

## 2.11 GEAR REDUCTION UNITS

A. Design and performance criteria:
   1. Gear type:
      a. Helical or herringbone.
   2. AGMA Class II service:
      a. Use more severe service condition when such is recommended by unit's manufacturer.
   3. Cast-iron housing with gears running in oil.
   4. Anti-friction bearings.
   5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.

## 2.12 MOUNTING AND LIFTING PROVISIONS FOR EQUIPMENT

A. Equipment bases and base plates:
   1. Provide equipment bases with machined support pads, dowels for alignment for mating of adjacent items, openings for electrical conduits, and openings to facilitate grouting.
   2. Provide jacking screws in bases and supports for equipment and for equipment weighing 500 pounds or more.
   3. Materials:
      a. Match equipment material or steel.
      b. Coating: Match equipment.

B. Steel support frames:
   1. Carbon steel:
      a. At exterior locations, and at interior wet or moist locations, provide continuous welds on both sides to close seams and edges between steel members.
      b. Grind closure welds smooth.

C. Lifting lugs or eyes:
   1. Equipment units weighing 50 pounds or more:
      a. Provide with lifting lugs or eyes to allow removal with lifting device.

## 2.13 NAMEPLATES

A. Fastened to equipment at factory in an accessible and visible location.

B. Metal engraved or stamped with text, holes drilled or punched for fasteners.

C. Material: Aluminum or stainless steel.

D. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.

E. Text:
   1. Manufacturer's name, equipment model number, equipment serial number, and identification tag number.
   2. Additional items indicated in the Technical Sections.
   3. Indicate the following additional information as applicable:
      a. Maximum and normal rotating speed.
      b. Service class per applicable standards.
   4. Include for pumps:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   5. Include for motors:
      a. Drive speed.
      b. Motor horsepower with rated capacity.
   6. Include for gear reduction units:
      a. AGMA class of service.
      b. Service factor.
      c. Input and output speeds.

## 2.14 PUMP SHAFT COUPLINGS

A. General:
   1. Type and ratings: Non-lubricated designed for not less than 50,000 hours of operating life.
   2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, balance, and type of service.
   3. Suitable for an ambient temperature range between -40 degrees to +200 degrees Fahrenheit.

B. Close-couplings for electric-motor-driven equipment:
   1. Manufacturers: One of the following or equal:
      a. Lovejoy.
      b. T.B. Woods.
   2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
   3. Manufacture flexible component of coupling from synthetic rubber or urethane.
   4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
   5. Do not allow metal-to-metal contact between driver and driven equipment.

C. Flexible couplings for direct connected electric-motor-driven equipment:
   1. Manufacturers: One of the following or equal:
      a. Rexnord.
      b. T.B. Woods.
   2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
   3. Provide flexible connecting element of rubber and reinforcement fibers.
   4. Provide service factor of 2.0.
   5. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings:
   1. Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment.

## 2.15 PUMP SEAL CHAMBER AND SEALS

A. Seal chamber (stuffing box):
   1. Large enough to retrofit with double mechanical seal.

B. Seal Types: Based on the following and as specified in the Technical Section:
   1. Type 1: Packing:
      a. Provide when specified in the Technical Section for wastewater, non-potable water, and sludge applications:
         1) Asbestos free.
         2) PTFE (Teflon™) free.
         3) Braided graphite.
         4) Manufacturers: One of the following or equal:
            a) Chesterton, 1400.
            b) John Crane.
      b. Provide when specified for drinking water service:
         1) Asbestos free.
         2) Material: Braided PTFE (Teflon™).
         3) Manufacturers: One of the following or equal:
            a) Chesterton, 1725.
            b) John Crane.
      c. Design:
         1) Packing gland to allow adjustment and repacking without dismantling pump except to open up stuffing box.
         2) Seal chamber (stuffing box) large enough to retrofit with double mechanical seal.
         3) Manufacturers: One of the following or equal:
            a) Chesterton, 1725.
            b) John Crane.
   2. Type 2: Mechanical seal, flushing, cartridge, single O-ring.
      a. Manufacturers: One of the following or equal:
         1) Chesterton, S10.
         2) John Crane, 5610 Series.

3. Type 3: Mechanical seal, flushing, cartridge, double O-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, S20.
        2) John Crane, 5620 Series.
4. Type 4: Mechanical seal, flushing, cartridge, double split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, S20.
        2) John Crane, 5620 Series.
5. Type 5: Mechanical seal, flushing, cartridge, single split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 442.
        2) John Crane, 5860.
6. Type 6: Mechanical seal, flushless, cartridge, single split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 156.
        2) John Crane, 3740 Series.

C. Mechanical seals, Types 2 to 6:
1. Balanced hydraulically.
2. Spring:
    a. Stationary, out of pumping fluid.
    b. Material as specified in the Technical Section. Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
3. O-ring: Viton™ 747.
4. Gland: Type 316L stainless steel.
5. Set screws: Type 316L stainless steel.
6. Faces: Reaction bonded, silicon carbide/carbon.
7. Minimum differential pressures in either direction: 300 pounds per square inch gauge.
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 1400.
        2) John Crane, equivalent product.
8. Drinking water service:
    a. Asbestos free.
    b. Material: Braided PTFE (Teflon™).
    c. Manufacturers: One of the following or equal:
        1) Chesterton, 1725.
        2) John Crane, equivalent product.

D. Flushing system:
1. Provide flushing connections:
    a. 3/4-inch size.
    b. Provide API Standard 682 seal water plan arrangement as specified in the Technical Section:
        1) Plan 11 - Product stream seal water from discharge thru seal.
        2) Plan 13 - Product stream seal water thru seal to suction.
        3) Plan 23 - Closed loop seal water with cooler and pumping ring.
        4) Plan 32 - Production seal water discharged to product stream.
        5) Plan 54 - Production Seal Water Excluded from Product Stream.

## 2.16 SAFETY SIGNS

A. Material, sign size, and text: As specified in Section 10400 - Signage.

## 2.17 SHIPPING

A. Prior to shipment of equipment:
   1. Bearings (and similar items):
      a. Pack separately or provide other protection during transport.
      b. Greased and lubricated.
   2. Gear boxes:
      a. Oil filled or sprayed with rust preventive protective coating.
   3. Fasteners:
      a. Inspect for proper torques and tightness.

# PART 3 EXECUTION

## 3.01 PRE-INSTALLATION

A. Field measurements:
   1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

B. Sequencing and scheduling:
   1. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
   2. Equipment anchoring: Obtain anchoring material and setting drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

## 3.02 LUBRICATION LINES AND FITTINGS

A. Support and protect lines from source to point of use.

B. Fittings:
   1. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
   2. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
   3. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

## 3.03 ALIGNMENT OF DRIVERS AND EQUIPMENT

A. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after driven equipment has been leveled on its foundation.

B. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
   1. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
   2. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.

C. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.

D. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.

E. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
   1. Allow minimum 48 hours for grout to harden.
   2. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
   3. Correct alignment as required.

## 3.04 EQUIPMENT SUPPORT AND ANCHORING TO STRUCTURES

A. Anchor equipment to structures as indicated on the Drawings and as specified.

B. Obtain final anchor bolt layouts for equipment prior to:
   1. Detailing reinforcement for equipment pads.
   2. Preparation of shop drawings for metal structures supporting equipment.

C. Anchor bolt templates:
   1. Provide templates as specified in the Technical Sections.
   2. Use final anchor bolt layout to construct templates for setting anchor bolts.
   3. Make templates:
      a. Rigid, and non-deformable during use.
      b. With longitudinal axes of anchors parallel.
      c. With longitudinal axes of anchors perpendicular to surface supporting the equipment.
   4. Templates may be reused for multiple locations of the same equipment only if:
      a. Templates are in "like-new" condition prior to each reuse.

b. The anchor layout has not been deformed or damaged by previous installation, removal, or handling of templates.

5. Sequence:
   a. Set and support templates prior construction of structures surrounding anchors.
   b. Position anchors in templates to provide designated embedment in supporting structure, with required projection for installation of grout, base plates, and hardware for tightening.
   c. Construct concrete or masonry around anchors using methods that preserve required anchor positions and alignment, and clearances to edges of supports or structures.

D. Anchor adjustment sleeves:
   1. Use of adjustment sleeves around anchors:
      a. Is at the option of the Contractor.
      b. Does not relieve Contractor of obligation to construct and use templates for setting of anchors.
      c. May required increased anchor embedment length to develop the strength of the anchor in the embedded length below the adjustment sleeve.
   2. Submittal requirements for anchor adjustment sleeves:
      a. Provide within sufficient time for Engineer approval and not less than 10 working days before setting those items.
      b. Proposed locations of sleeves.
      c. Details and dimensions of sleeves.
      d. Sleeve materials of construction, and coatings.
      e. Information on sleeve filler material and means of filler removal.
      f. Type, details, and dimensions of anchor bolts or anchor rods to be used with sleeves.
      g. Calculations showing development of anchor load capacity below the bottom of the sleeve.
      h. Plan for removal of sleeve fillers, if any.
      i. Plan for placement and consolidation of flowable grout inside sleeves and to a level equal to top of concrete slab or equipment pad surrounding the sleeve.

## 3.05 GROUTING UNDER EQUIPMENT BASES, BASE PLATES, SOLE PLATES, AND SKIDS

A. General:
   1. Comply with equipment manufacturer's installation instructions including:
      a. Tolerances for level.
      b. Tolerances for vertical and horizontal alignment.
      c. Requirements or recommendations for grouting spaces and grout installation.
      d. Recommendations for tightening of equipment anchors after grout has cured.
   2. Install equipment over grout as indicated on the Drawings or specified only after:
      a. Equipment is leveled and in proper alignment.
      b. Piping connections are complete and in alignment with no strain transmitted to equipment.

3. Install flowable grout, as specified in Section 03600 - Grouting, placed with forms and head boxes.
    a. Use flowable, non-shrink grout.
    b. Use flowable, non-shrink epoxy grout, only where indicated on the Drawings, where specified in Technical Sections, or when approved in advance by the Engineer.
    c. Grouting with dry-pack materials is not permitted.

B. Prepare equipment bases, base plates, soleplates, and skids for grouting:
    1. Concrete equipment bases:
        a. Roughen surface in accordance with ICRI, Guideline No. 310.2R, Surface Preparation Profiles CSP-3 and CSP-4.
        b. Clean roughened concrete surfaces:
    2. Base plates, soleplates, and skids:
        a. Clean surfaces in accordance with SSPC-SP-1-Solvent Cleaning, to remove dirt, dust, oil, grease, paint, and other material.

C. Level equipment for grouting:
    1. Use removable jack screws, or removable steel wedges and shims to support and level equipment bases, base plates, sole plates, and skids.
        a. Do not use leveling nuts placed on equipment anchors to support or level equipment bases, base plates, sole plates, and skids.
    2. Removable jack screws:
        a. Provide number, size, and locations of jack screws required to support and level equipment in accordance with manufacturer's recommendations.
        b. Drill and tap equipment base plates, sole plates, and skids for jack screws.
        c. Support jack screws on circular steel plates that have been epoxy bonded to the equipment foundation.
            1) Provide plates fabricated from Type 316 stainless steel where edges of support plates will have grout side cover of 3 inches or less in the finished work.
        d. Make provision for removal of jack screws after grouting:
            1) Prevent grout from bonding to jack screws by wrapping jack screw threads that will be in contact with grout with multiple layers of tape or other material acceptable to Engineer.
        e. Place and cure grout.
        f. After grout is placed and cured:
            1) Remove jack screws and material used to prevent grout from bonding to jack screws.
            2) Provide jack screws to Owner for future use.
            3) Fill jack screw holes with grout.
            4) Cure grout as specified.
    3. Removable steel wedges and shims:
        a. Use for equipment bases, base plates, sole plates, and skids where it is not practical to use jack screws.
        b. Provide number, size, and locations of wedges and shims required to support and level equipment in accordance with manufacturer's recommendations.

c. Make provision for removal of wedges and shims after grouting:
    1) Prevent grout from bonding to wedges and shims by wrapping wedges and shims that contact grout with multiple layers of tape or other material acceptable to Engineer.
    2) Locate and orient wedges and shims to allow for removal after grouting, and to facilitate placement of grout in the remaining voids.
d. Place and cure grout.
e. After grout is placed and cured:
    1) Remove wedges and shims, and material used to prevent grout from bonding to them.
    2) Fill jack screw holes with grout.
    3) Cure grout as specified.

D. Construct grout forms:
1. Provide forms:
    a. Rigid with adequate strength to withstand placement of grout.
    b. With surfaces that will produce a smooth, uniform finish for grout edges exposed in the finished work.
    c. That allow grout to flow horizontally beyond the perimeter of the equipment base plate a distance not less than the thickness of the grout, and not less than 1 inch.
2. Install forms:
    a. Seal form cracks and joints with elastomeric sealant to make form watertight.
    b. Line form surfaces in contact with grout with polyethylene film, or coat with 2 coats of heavy-duty paste wax.
3. Construct grout "head box" over entire length of one side of form.
    a. Make head box height sufficient to force grout to flow under full dimensions of equipment base and to the surrounding form faces.

E. Pre-grouting procedures:
1. Concrete surfaces receiving flowable, non-shrink grout:
    a. Saturate concrete surface in contact with grout and concrete surfaces extending not less than least 6 inches beyond limits of grout with clean water for a minimum of 24 hours prior to grouting.
    b. Just prior to grout placement, remove standing water using clean rags or oil-free compressed air. Provide "saturated surface dry" (SSD) concrete for grout placement.
2. Concrete surfaces receiving flowable, non-shrink epoxy grout:
    a. Do not saturate concrete prior to grout placement.

F. Grout placement and curing:
1. Place and cure grout as specified in Section 03600 - Grouting, and in this Section.
2. Grouting:
    a. Keep level of grout in head box above bottom of equipment bases, base plates, sole plates, and skids always to drive flow under base.
    b. Maintain continuous grout flow from head box to opposite sides of forms without trapping air or forming voids.
    c. Vibrate, rod, or chain grout to facilitate grout flow, to consolidate grout, and to remove entrapped air.

3. After grout sets, remove forms and trim grout edges at 45-degree angle from bottom edge of equipment bases, base plates, sole plates, and skids.
4. Cure grout as specified in Section 03600 - Grouting.

G. After grout is cured:
1. Remove jack screws or wedges and shims, and material used to prevent grout from bonding to leveling devices.
2. Fill pockets from removed leveling devices with grout.
3. Cure filled voids as specified in Section 03600 - Grouting.
4. Tighten equipment anchors in accordance with equipment manufacturer requirements.

## 3.06 FIELD FINISHES

A. When touchup or repair is required, apply primer and coating systems as recommended by the equipment manufacturer.

END OF SECTION

## SECTION 15052

## COMMON WORK RESULTS FOR GENERAL PIPING

### PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: 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 24.
   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. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   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. 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. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

## 1.03 DEFINITIONS

A. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.

B. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.

C. Underground pipes: Buried pipes - see A. above.

D. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.

E. Wet wall: A wall with water on at least 1 side.

F. Pipes adjacent to a wet wall: Pipe centerline within 10 inches of the wet wall.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

## 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 1/8 inch minimum.
      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 underwater pipes and pipes adjacent to wet walls:
    a. Bolts: In accordance with ASTM A193, Grade B8M.
    b. Nuts: In accordance with ASTM A194, Grade 8M.
4. On buried pipes:
    a. Bolts: In accordance with ASTM A193, Grade B8M.
    b. Nuts: In accordance with ASTM A194, Grade 8M for nuts.
    c. Bolts: In accordance with ASTM A307, Grade B.
    d. Nuts: In accordance with ASTM A563, Grade A.
    e. Encase in 2 layers of loose polyethylene wrap in accordance with AWWA C105.
    f. Bolts: In accordance with ASTM A193, Grade B7.
    g. Nuts: In accordance with ASTM A194, Grade 2H.
    h. Coat with high solids epoxy and encase in 2 layers of loose polyethylene wrap in accordance with AWWA C105.
    i. Bolts and nuts: Hex head Hastelloy C276.

C. Plastic pipe:
1. On exposed pipes:
    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 underwater pipes and pipes adjacent to wet walls:
    a. Bolts: In accordance with ASTM A193, Grade B8M.
    b. Nuts: In accordance with ASTM A194, Grade 8M.

D. Steel pipe:
1. On exposed pipes:
    a. For ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges:
        1) Bolts: In accordance with ASTM A307, Grade B.
        2) Nuts: In accordance with ASTM A563, Grade A.
        3) Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
    b. For ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges:
        1) Bolts: In accordance with ASTM A193, Grade B7.
        2) Nuts: In accordance with ASTM A194, Grade 2H.

2. On underwater pipes and pipes adjacent to wet walls:
    a. Bolts: In accordance with ASTM A193, Grade B8M.
    b. Nuts: In accordance with ASTM A194, Grade 8M.
3. Low-temperature service: Stainless steel, Type 316:
    a. Bolts: In accordance with ASTM A320, Grade B8M, Class 1, heavy hex.
    b. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
    c. Washers: Alloy group matching bolts and nuts.
4. High-temperature service or high-pressure service: Stainless steel, Type 316:
    a. Bolts: In accordance with ASTM A193, Grade B8M, Class 1, heavy hex.
    b. Nuts: In accordance with ASTM A194, Grade 8, heavy hex.
    c. Washers: Alloy group matching bolts and nuts.

## 2.04 MECHANICAL JOINTS BOLTS AND NUTS

A. Bolts including T-Bolts:
1. High strength low alloy steel in accordance with AWWA C111.
    a. Fluoropolymer coated.
2. Type 304 stainless steel in accordance with ASTM F593.
3. Type 316 stainless steel in accordance with ASTM F593.

B. Heavy Hex Nuts:
1. High strength low alloy steel in accordance with AWWA C111.
    a. Fluoropolymer coated.
2. Type 304 stainless steel in accordance with ASTM F594.
3. Type 316 stainless steel in accordance with ASTM F594.

## 2.05 GASKETS

A. General.
1. Gaskets shall be 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. Gaskets for flanged joints in ductile iron and steel piping for sewage service:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and raw sewage service.
2. Gasket material:
    a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
    a. Reinforcement: Cloth or synthetic fiber.
    b. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
3. Manufacturers: One of the following or equal:
    a. Pipe less than 48 inches in diameter:
        1) Garlock, Style 7797.
        2) John Crane, similar product.
    b. Pipe 48 inches in diameter and larger:
        1) Garlock, Style 3760.
        2) John Crane, similar product.

C. Gaskets for steam cleaned non-glass-lined ductile iron and steel piping:
   1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 360 degrees Fahrenheit, and raw sewage service.
   2. Material:
      a. Neoprene elastomer, compressed, non-asbestos fiber reinforcement.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Bluegard 3300.
      b. John Crane, similar product.

D. Gaskets for steam cleaned glass lined ductile iron piping:
   1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 360 degrees Fahrenheit, and sludge service.
   2. Material:
      a. Teflon™ gasketing with 1/16-inch sheet thickness each side (1/8-inch total sheet thickness), filled with corrugated or perforated Type 316 stainless steel ring and non-asbestos filler material with minimum 5/16-inch overall thickness.
   3. Manufacturers: One of the following or equal:
      a. Garlock, Style HP3561.
      b. John Crane, similar product.

E. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
   1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to and less than 120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
   2. Material:
      a. Chemical systems: 0.125-inch thick Viton™ rubber.
      b. Sewer and water: 0.125-inch thick SBR.
   3. Manufacturers: One of the following or equal:
      a. Garlock.
      b. John Crane, similar product.

F. Gaskets for flanged joints in gas or liquefied petroleum gas piping:
   1. Digester gas in stainless steel, or black steel piping: Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 200 degrees Fahrenheit, and digester gas and mild acid concentrations.
   2. Chlorine gas application in black steel piping: Suitable for pressures equal to or less than 300 pounds per square inch gauge, temperatures equal to or less than 100 degrees Fahrenheit, and chlorine gas application.
   3. Liquefied petroleum, propane, and natural gas applications in black steel piping: Suitable for pressures equal to and less than 250 pounds per square inch gauge, temperatures equal to and less than 100 degrees Fahrenheit, and liquefied petroleum gas, propane gas, and natural gas application.
   4. Material:
      a. Microcellular Teflon™ outer layers with rigid center layer.

b. Sealability in accordance with ASTM F37, less than 0.55 millimeters per hour leakage of iso-octane at 1,000 pounds per square inch gasket load and 9.8 pounds per square inch fluid pressure.

5. Manufacturers: One of the following or equal:
   a. Garlock, Style 3545.
   b. John Crane, similar product.

G. Gaskets for flanged joints in low pressure air piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 300 degrees Fahrenheit, and compressed air service.
2. Material: EPDM elastomer, 1/8-inch thick, 60 Shore hardness, smooth surface.
3. Manufacturers: One of the following or equal:
   a. Garlock, Style 8314.
   b. John Crane, similar product.

H. Gaskets for flanged joints in ductile iron or steel water piping:
1. Suitable for hot or cold water, pressures equal to and less than 150 pounds per square inch gauge, and temperatures equal to and less than 160 degrees Fahrenheit.
2. Material:
   a. SBR or neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
   b. Teflon™ ring; or Teflon™ envelope with non-asbestos filler.
3. Manufacturers: One of the following or equal:
   a. Garlock, Bluegard 3300.
   b. John Crane, similar product.

I. Gaskets 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 1 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.
    e. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.

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 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: As specified in Sections 15061 - Pipe Supports, 15062 - Preformed Channel Pipe Support System, and 15063 - Non-Metallic Pipe Support System:
    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.
4. Concrete encase buried pipe installed under concrete slabs or structures.

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 in as specified in Section 09960 - High-Performance Coatings.

F. Condensate in digester gas piping:
1. Slope digester gas piping to drip traps or low-point drains at minimum 1/2-inch per foot where condensate flows against the gas or 1/4-inch per foot where condensate flows with gas.
2. Install tapered filler pieces between flanges at high points of straight runs to provide for slope reversals.
    a. Do not subject piping to high stresses in order to change direction.
3. Provide pipe taps, threaded nipples, and 1-inch plug valves at low points in concrete utility boxes with lids.

G. Restraining buried piping:
1. Restrain piping 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 Piping Schedule.

H. Restraining above ground piping:
   1. Restrain piping 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.

I. 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.

J. 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.

K. 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. Cleaning air piping:
   1. Perform special cleaning of filtered air piping from the intake clean air plenums to the discharge points and high-pressure air piping.
      a. Protect surfaces from contamination.

2. Special cleaning shall include wire brushing, power tool cleaning, wiping down with lint-free cloths, brooming, and vacuuming to remove rust, scale, weld spatter, dust, dirt, oil, and other matter deleterious to operation of the air system:
    a. Do not sandblast installed piping.
3. To the greatest extent possible, clean piping immediately prior to final closure of piping systems:
    a. Enter piping, clean and wipe down surfaces, and vacuum out residue.
    b. Clean surfaces not accessible to this cleaning operation after installation within 6 hours preceding installation.
4. Subsequent to cleaning, protect surfaces from contamination by dust, dirt, construction debris, and moisture, including atmospheric moisture:
    a. Whether or not pipe upstream has been cleaned, temporarily seal openings in partially completed work except when installation is actively in progress.
    b. When installation is actively in progress, seal openings at the end of each day's construction or when construction is temporarily stopped.
5. Suspend cleaning and seal openings when inclement weather, including dust storms, is imminent.
6. Use clean, dry air for testing the piping and other elements of the system.
7. Prior to introduction of air to the system, blow piping clean.
    a. Blow with maximum discharge rate possible for minimum 4 hours, using new blowers or compressors and filters.
8. Clean surfaces that become contaminated prior to acceptance.

## 3.03 PIPING SCHEDULE

A. As indicated on the Drawings.

END OF SECTION

# SECTION 15061

# PIPE SUPPORTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

B. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures

B. Product data.
   1. Design features.
   2. Load capacities.
   3. Material designations by UNS alloy number or ASTM Specification and Grade.
   4. Data needed to verify compliance with the Specifications.
   5. Catalog data.
   6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

### 1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

## 2.02 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05120 - Structural Steel Framing.
      b. Hot dip after fabrication of support in accordance with ASTM A123.
      c. Repair galvanized surface as specified in Section 05120 - Structural Steel Framing.
   2. Stainless steel.
      a. Fabricate as specified in Section 05120 - Structural Steel Framing.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
      c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or A967.
         1) Passivation treatments using citric acid are not allowed.
      d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
   1. Hot Dip Galvanized.

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
   1. Hot Dip Galvanized.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
   1. Type 316 Stainless Steel.

E. Stainless steel piping system:
   1. Type 316 Stainless Steel.

F. Chemical containment areas and chemical piping:
   1. Type 316 Stainless Steel.

G. Fasteners:
   1. As specified in Section 05120 - Structural Steel Framing.

## 2.03 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 133.
         2) Nibco-Tolco, Figure 103.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 140.
         2) Bergen-Power, Figure 133.
         3) Cooper B-Line Systems, Inc., Figure B3205.

B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 94.
         2) FM Stainless Fasteners.
      b. For steel and ductile iron piping:
         1) Anvil International, Figure 146.
         2) Bergen-Power, Figure 94.

C. Eye bolts:
   1. For stainless steel piping:
      a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
   2. For all other piping, unless indicated on the Drawings:
      a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 101.
         2) FM Stainless Fasteners.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 278.
         2) Bergen-Power, Figure 93.
         3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1C.I.
         2) Bergen-Power, Figure 100SS.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 69.
         2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-58, Type 1:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
         2) FM Stainless Fasteners, Figure 60.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 260 or Figure 590.
         2) Bergen-Power, Figure 100.
         3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1A.

b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 300.
2) Bergen-Power, Figure 100EL.
3) Cooper B-Line Systems, Inc. Figure B3108.

H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 324.
2) Cooper B-Line Systems, Inc., Figure B3110.
3) FM Fasteners, Figure 81.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 181.
2) Cooper B-Line Systems, Inc., Figure B3110.

I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) FM Stainless Fasteners, Figure 71.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 171.
2) Cooper B-Line Systems, Inc., Figure B3114.

J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 30M.
2) Cooper B-Line Systems, Inc., Figure B3066.
3) FM Stainless Fasteners, Figure 98.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 195.
2) Cooper B-Line Systems, Inc., Figure B3066.

K. Brackets, heavy duty: MSS SP-58, Type 33 with back plate; rated for 3,000 pounds:
1. Manufacturers: One of following or equal:
a. Anvil International, Figure 199.
b. Cooper B-Line Systems, Inc., Figure B3067.

L. Standard U-bolt: MSS SP-58, Type 24:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 110.
2) Cooper B-Line Systems, Inc., Figure B3188.
3) FM Stainless Fasteners, Figure 37.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 137.
2) Bergen-Power, Figure 283.
3) Cooper B-Line Systems, Inc., Figure B3188.

M. Riser clamps: MSS SP-58, Type 8:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Cooper B-Line Systems, Inc., Figure B3373.
            2) FM Stainless Fasteners, Figure 61.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 261.
            2) Bergen-Power, Figure 126.
            3) Cooper B-Line Systems, Inc., Figure B3373.

N. Pipe clamps: MSS SP-58, Type 4:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 4.
            2) Cooper B-Line Systems, Inc., Figure 3140.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 212.
            2) Bergen-Power, Figure 175.
            3) Cooper B-Line Systems, Inc., Figure B3140.

O. Adjustable offset pipe clamp:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 4.
            2) Cooper B-Line Systems, Inc., Figure B3149.
            3) FM Stainless Fasteners, Figure 63.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 100.
            2) Cooper B-Line Systems, Inc., Figure B3149.

P. Offset pipe clamp:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 8.
            2) Cooper B-Line Systems, Inc., Figure 3148.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 103.
            2) Cooper B-Line Systems, Inc., Figure B3148.

Q. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
    1. Manufacturers: One of the following or equal:
        a. For stainless steel piping:
            1) Nibco-Tolco, Figure 318.
            2) FM Stainless Fasteners, Figure 59.
        b. For all other piping, unless indicated on the Drawings:
            1) Anvil International, Figure 259.
            2) Bergen-Power, Figure 125.
            3) Cooper B-Line Systems, Inc., Figure B3090.
        c. Threaded pipe stand support stanchion. Match pipe support material.
            1) Anvil International, Figure 63T.

2) Bergen-Power, Figure 138.
3) Cooper B-Line Systems Inc., Figure B3088ST.

R. Spring hangers:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Bergen-Power, Figure 920.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure B-268, Type G.
2) Bergen-Power, Figure 920.

S. One hole pipe clamps:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping: Engineer knows of no product.
b. For all other piping:
1) Anvil International, Figure 126.
2) Carpenter & Paterson, Figure 237S.

T. Welded beam attachment: MSS SP-58, Type 22:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 304.
2) Cooper B-Line Systems, Inc., Figure 3083.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 66.
2) Bergen-Power, Figure 113A or 113B.
3) Cooper B-Line Systems, Inc., Figure B3083.

U. Heavy pipe clamp: MSS SP-58, Type 4:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 4H.
b. For all other piping, unless called out otherwise on the drawings:
1) Anvil International, Figure 216.
2) Bergen-Power, Figure 298.

V. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 426.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 257, Type 3.
2) Cooper B-Line Systems, Inc., Figure B3893.

W. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120 - Structural Steel Framing.

## 2.04 THERMAL PIPE HANGER SHIELD

A. Thermal shields shall be provided at hanger, support and guide locations on pipe requiring insulation.

B. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer.

C. The thermal shield shall be the same thickness as the piping system insulation specified in Section 15082 - Piping Insulation.

D. The standard shield shall be used for hot systems and the vapor barrier shield shall be used for cold systems.

E. Stainless steel band clamps shall be used where specified to protect against slippage between the pipe wall and the thermal shield.

F. Standard shield:
   1. Insulation:
      a. Hydrous calcium silicate, high density, waterproof.
      b. Compressive strength: 100 pounds per square inch average.
      c. Flexural strength: 75 pounds per square inch average
      d. K factor: 0.38 at 100 degrees Fahrenheit mean.
      e. Temperature range: 20 degrees Fahrenheit to 500 degrees Fahrenheit.
   2. Steel jacket:
      a. The jacket shall be galvanized steel.
      b. Gage shall be the manufacturer's standard supplied for the given pipe size.
   3. Connection:
      a. Shield shall have butt connection to pipe insulation.
      b. Steel jacket and insulation ends shall be flush.

G. Vapor barrier shield:
   1. Insulation:
      a. Hydrous calcium silicate, high density, waterproof.
      b. Compressive strength: 100 pounds per square inch average.
      c. Flexural strength: 75 pounds per square inch average.
      d. K factor: 0.38 at 100 degrees Fahrenheit mean.
      e. Temperature range: 20 degrees Fahrenheit to 500 degrees Fahrenheit.

H. Steel jacket:
   1. The jacket shall be of galvanized steel.
   2. Gage shall be the manufacturer's standard supplied for the given pipe size.

I. Connection:
   1. Shield shall have butt connection to pipe insulation.

J. Insulation shall extend 1 inch each side of steel jacket for vapor tight connection to the pipe insulation vapor barrier.

## PART 3 EXECUTION

## 3.01 INSTALLATION

A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1-inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
   1. For stainless steel piping, use stainless steel U-bolts.
   2. For all other piping, use galvanized U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
   5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

M. Install supports at:
   1. Any change in direction.
   2. Both sides of flexible pipe connections.

3. Base of risers.
4. Floor penetrations.
5. Connections to pumps, blowers, and other equipment.
6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.

R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410 - Regulatory Requirements.

T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

U. Where pipe is insulated, install over-sized supports and hangers.

V. Install thermal pipe shield in accordance with MSS SP-58, Type 40 on all pipe supports for insulated pipes.

W. Install riser clamps at floor penetrations and where indicated on the Drawings.

X. Coat support system components as specified in Section 09960 - High-Performance Coatings.

END OF SECTION

## SECTION 15062

## PREFORMED CHANNEL PIPE SUPPORT SYSTEM

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

### 1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Iron and Steel Institute (AISI).

C. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data.

### 1.04 QUALITY ASSURANCE

A. Design preformed channel pipe support system for loads in accordance with applicable provisions of:
   1. AISC Manual of Steel Construction.
   2. AISI Cold-Formed Steel Design Manual.

B. Product standards:
   1. Pipe support materials: In accordance with MSS SP-58.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
   1. Manufacturers: One of the following or equal:
      a. Unistrut, Series P1000 or P1001; P5500 or P5501.
      b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
      c. Cooper Ind., B-Line, Channel Type B22 or B22A; B12 or B12A.

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design responsibility:
   1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design criteria:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Minimum gauge thickness: 12-gauge.
   3. Allowable stress of channels:
      a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
      b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.
   4. Maximum deflection: 1/240 of span.
   5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
   6. Future loads:
      a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
      b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
      c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
   7. Seismic design criteria: As specified in Section 01850 - Design Criteria as specified for mechanical equipment.
   8. Spacing of supports: As required to comply with design requirements but not more than 5 feet.

C. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
   1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

## 2.03 ACCESSORIES

A. Preformed channel concrete inserts: Minimum 12 inches long:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, Series P-3200.
      b. Allied Support Systems, Figure 282.
      c. Cooper Ind., B-Line Series B32I.

B. 90 degree angle fittings:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P1026.
      b. Allied Support Systems, Power Strut, P603.

C. Pipe straps:
   1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
      a. Manufacturers: One of the following or equal:
         1) Unistrut, Series P1109 through P1126.
         2) Allied Support Systems, PS1100.
         3) Cooper Ind., B-Line Series B2000.
   2. For pipes greater than 8 inches in diameter: Unless different material is otherwise indicated on the Drawings, use one piece that is 1 inch wide by 1/8 inch thick steel strap, hot-dip galvanized after fabrication.
   3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above, but use Type 316 stainless steel materials.

D. Prefabricated double channel bracket:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P2542-P2546.
      b. Cooper Ind., B-Line Series B297.

E. Touch-up paint for galvanized surfaces:
   1. Manufacturers: The following or equal:
      a. Galvinox, Galvo-Weld.

F. Touch-up paint for painted surfaces: Same formulation as factory paint.

G. Cushion strip:
   1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets these criteria.
      a. Manufacturers: One of the following or equal:
         1) Anvil, AS 3795.
         2) Unistrut, P2600 Unicushion.

## 2.04 FABRICATION

A. Hot-dip galvanize support system components after fabrication to required length and shape.

B. Do not galvanize or paint stainless steel components.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.

B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.

C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.

D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.

E. Touchup cut or damaged galvanized surfaces.

F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.

G. Install support as near as possible to concentrated loads.

H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.

I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

# SECTION 15076

# PIPE IDENTIFICATION

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification by color and legend.
   2. Underground warning tape.
   3. Tracer wire.
   4. Witness markers.
   5. Valve identification.

### 1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770 - Closeout Procedures:
      a. Operation and Maintenance Data.
      b. Warranty.

## PART 2 PRODUCTS

### 2.01 ABOVE GROUND AND IN-CHASE PIPE IDENTIFICATION

A. Pipe Markers:
   1. Manufacturers: One of the following or equal:
      a. Seton, Opti Code Pipe Markers.
      b. Lab Safety Supply.
      c. Marking Services, Inc.
   2. Materials:
      a. Pipe markers: Self-adhesive vinyl, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.

3. Lettering:

| Outside Pipe Diameter Including Covering | Lettering Size |
|---|---|
| Less than 1.5 inches | 1/2-inch |
| 1.5 inches to 2 inches | 3/4-inch |
| 2.5 inches to 4 inches | 1-1/4 inches |
| 8 inches to 10 inches | 2-1/2 inches |
| Over 10 inches | 3-1/2 inches |

a. Marker colors:

| Service | Lettering | Background |
|---|---|---|
| Flammables, chemicals, toxics | Black | Yellow |
| Water, nontoxic solutions or low hazard liquids | White | Green |
| Nonflammable or nontoxic gases | White | Blue |
| Fire quenching fluids (foam, fire water, $CO_2$ Halon) | White | Red |

4. Coating: As specified in Section 09960 - High-Performance Coatings.
5. Pipe identification tags: Aluminum or stainless steel with stamped-in 1/4-inch-high identifying lettering.
6. Pipe identification tag chains: Aluminum or stainless steel.
7. Snap-on markers: Markers with 3/4-inch-high letters for 3/4 to 4-inch pipe or covering, or 5-inch-high letters for 5-inch or larger pipe or cover:
   a. Manufacturers: One of following or equal:
      1) Brady BradySnap-On B-915.
      2) Seton Setmark.

## 2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton Name Plate Co.
      b. T. Christy Enterprises, Inc.

   2. Material:
      a. Polyethylene tape for prolonged underground use.
      b. Minimum tape thickness: 4 mils.
      c. Overall tape width: 4 inches.
      d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW.” in black lettering on colored background in accordance with approved APWA colors.
         1) Water: Blue.
         2) Sewer: Green.
         3) Telephone: Orange.

4) Gas and other services: Yellow.
e. Aluminum backing or solid aluminum core.

B. Tracer wire:
1. Manufacturers: One of the following or equal:
a. Kris-Tech Wire.
b. Corrpro.

2. Materials: One of the following or equal:
a. Solid copper conductor
b. Thickness minimum: 10 gauge.
c. Insulation:
1) Match insulation color to the color of the pipe being installed.
2) UF type, direct bury.
3) 30 mil HMWPE.
3. Splicing Kit:
a. Manufacturers: One of the following or equal:
1) Rexel, 3M-82 A1N.
4. Station Box:
a. Lid and collar materials: Cast iron.
b. Able to withstand heavy traffic loading.
c. Manufacturers: One of the following or equal:
1) Farwest Corrosion Control Co, Glenn 4 Test Station.

C. Witness markers:
1. Manufacturers: One of the following or equal:
a. Carsonite Composites, Utility Marker.
b. Hampton Technical Associates, Inc.

2. Materials:
a. Glass fiber and resin reinforced thermosetting composite material.
b. UV resistant.
3. Constructed as a single piece.
4. Pointed at the bottom end.
5. Information to be included on the marker:
a. “Caution” (type of service) “Pipeline”.
b. Phone number for Underground Service Alert.
c. Phone number for Owner in case of emergency.
d. Station number.
e. Offset:
1) Only provide offset if marker is not directly over the pipe.
f. Name of appurtenance or fitting (e.g. 45, BO, ARV, etc.)

## 2.03 VALVE AND GATE IDENTIFICATION

A. Provide valve and gate schedule for each valve and gate in the Work with the following information:
1. Identification number (for gates).
2. Location.
3. Type.
4. Function.

5. Normal operating position.

B. Identification tag requirements.
   1. Diameter: 2 inches.
   2. Material:
      a. Buried applications: Stainless steel, brass, or PVC.
      b. Buried applications with concrete marker: Brass.
      c. Above ground and in-chase applications: 19-gauge aluminum or PVC.
   3. Stamp tags in 1/4-inch-high letter:
   4. Provide non-corrosive metal wire suitable for attaching the tag to the operator base.
   5. Secure tags to valve or gate:
      a. Attach tags in such a way as to allow free and full operation of the valve or gate.
   6. Buried applications with concrete marker: Secure tags to concrete marker.

C. Submittal requirements:
   1. Submit 2 samples of the type of tag proposed and the manufacturer's standard color chart and letter styles to the Engineer for review.

D. Manufacturer: The following or equal:
   1. Seton Name Plate Co.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

### 3.02 PREPARATION

A. Prepare and coat surfaces as specified in Section 09960 - High-Performance Coatings.

B. Prepare surface in accordance with product manufacturer's instructions.

### 3.03 ABOVE GROUND AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed piping, valves, and accessories in accessible chases with lettering or tags designating service of each piping system with flow directional arrows and color code.

B. Color code:
   1. Paint piping with colors as scheduled in Piping Color Code and Marker Schedule.

C. Lettering and flow direction arrows:
   1. Stencil lettering on painted bands or use Snap-On markers on pipe to identify pipe. When stenciling, stencil 3/4-inch-high letters on 3/4 through 4-inch pipe or coverings, or 5-inch high letters on 5-inch and larger pipe or coverings.
   2. Provide lettering and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.

D. Where scheduled, space 4-inch-wide bands along stainless steel pipe at 10-foot intervals and other pipe at 5-foot intervals.

E. Label chemical tank fill pipelines at locations which are visible from chemical fill stations.

F. Metal tags:
   1. Where outside diameter of pipe or pipe covering is 5/8-inch or smaller, provide metal pipe identification tags instead of lettering.
   2. Fasten pipe identification tags to pipe with chain.
   3. Where tags are used, color code pipe as scheduled.

## 3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:
   1. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.

B. Tracer wire:
   1. Install on all non-metallic pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
   3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
   4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
      a. Twisting the wires together is not acceptable.

C. Witness markers:
   1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
   2. Place markers at appurtenances located in unpaved areas.
   3. Embed markers at least 18 inches into the soil.

## 3.05 APPLICATION

A. Identify piping with legend markers, directional arrow markers, and number markers; use self-adhesive arrow roll tape to secure ends of piping markers and indicate flow direction.

B. Provide legend markers, directional arrow markers, and number markers where piping passes through walls or floors, at piping intersections and at maximum 15-foot spacing on piping runs.

C. Provide piping marker letters and colors as scheduled.

D. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.

## 3.06 PIPING COLOR CODE AND MARKER SCHEDULE

| Service Fluid | Pipe Color | Marker Legend |
|---|---|---|
| Chemical Drain | Charcoal | CHEMICAL DRAIN |
| Cooling Water | Blue | COOLING WATER |
| Domestic Cold Water | Light Blue | DOMESTIC COLD WATER |
| Domestic Hot Water | Light Blue | DOMESTIC HOT WATER |
| Deionized Water | Blue | DEIONIZED WATER |
| Drain | Charcoal | DRAIN |
| Exhaust Gas | Yellow | EXHAUST GAS |
| Engine Jacket Water | Dark Blue | ENGINE JACKET WATER |
| Fuel Oil | Orange | FUEL OIL |
| Grit | Black | GRIT |
| Instrumental Air | Purple | INSTRUMENTATION AIR |
| Engine Lube Oil | Red | ENGINE LUBE OIL |
| Pumped Drain | Charcoal | PUMPED DRAIN |
| Process Water | Dark Blue | PROCESS WATER |
| Raw Wastewater | Buff | NONE USED |
| Return Water | Silver/Grey | RETURN WATER |
| Sample | Green | FLUID BEING SAMPLED |
| Sanitary Drain | Charcoal | SANITARY DRAIN |
| Service Air | Green | SERVICE AIR |
| Sodium Hypochlorite | Yellow | CHLORINE SOLUTION |
| Sodium Bisulfite | Yellow | SODIUM BISULFITE SOLUTION |
| Tank Drain | Charcoal | TANK DRAIN |
| Vent Pipe | Yellow | VENT PIPE |
| Washdown Water (W3) | Medium Blue | WASHDOWN WATER |

| Letters | Color of Pipe | Color of Bands | Color of Letters |
|---|---|---|---|
| Finished or Potable (cold) | Light blue | None | Black |
| Potable (hot) | Light blue | Red | Black |
| Non-potable or Raw | Light blue | Dark Gray | Black |
| Distilled or Demineralized | Light Blue | Black | Black |
| Service Water (lines downstream from backflow prevention unit | Dark Blue | White | Red |
| Sample | Dark Blue | Black | White |
| Fire Protection | Red | None | Black |
| Hydrants | Aluminum | None | Black |
| Filter-to-Waste | Light Brown | None | Black |
| Wash Water Drain | Light Gray | None | Black |
| Sewage | Light Gray | None | Black |
| Solids | Dark Brown | None | White |
| Scum | Dark Brown | None | White |
| Drain | Dark Gray | None | White |
| Sump Pump Pipeline | Dark Gray | Red | White |
| Chlorine (gas, liquid, or vent) | Yellow | None | Black |
| Chlorine (solution) | Yellow | Red | Black |
| Ferric Chloride | Orange | Yellow | Black |
| Alum | Orange | Yellow | Black |
| Ammonia | Yellow | Dark Brown | Black |
| Auxiliary Chemical | Yellow | Dark Blue | Black |
| Sulfuric Acid | Yellow | Orange | Black |
| Sodium Hydroxide | Yellow | Dark Green | Black |
| Algaecide (Potassium Permanganate, Copper Sulfate) | Orange | White | Black |
| Polymer | Orange | Dark Green | Black |
| Polyphosphate | Orange | Dark Gray | Black |
| Carbon | Black | None | White |
| Ozone | None | Red | White |
| Stainless Steel Pipe | White | Red | White |
| Ozone Off Gas | | | |

| Letters | Color of Pipe | Color of Bands | Color of Letters |
|---|---|---|---|
| Stainless Steel Pipe | None | Orange | White |
| Other Pipe | White | Orange | White |
| Compressed Air | Light Green | None | Black |
| Instrument Air | Light Green | Dark Green | Black |
| Backwash Air (Low Pressure) | | | |
| Stainless Steel Pipe | None | None | Black |
| Other Pipe | Light Green | None | Black |
| Process Air (Ozone-Low Pressure) | | | |
| Stainless Steel Pipe | None | None | Black |
| Other Pipe | Light Green | None | Black |
| Laboratory Vacuum | Dark Green | Light Green | Red |
| Natural Gas | Red | Yellow | White |
| Refrigerant | Yellow | White | Black |
| Heating Water (supply) | Light Gray | White | Black |
| Heating Water (return) | Light Gray | Black | Black |
| Condenser Water (supply) | Light Gray | Dark Brown | Black |
| Condenser Water (return) | Light Gray | Red | Black |
| Chilled Water (supply) | Light Brown | Dark Gray | White |
| Chilled Water (return) | Light Brown | Red | White |

END OF SECTION

## SECTION 15110

## 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 01330 - Submittal Procedures.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Power valve actuators:
         1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
         2) Complete wiring diagrams and control system schematics.
      d. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.

f. Certifications of reference standard compliance:
   1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
h. Factory test data.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - 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 01756 - Commissioning.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - 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 per Section 15112 - Butterfly Valves.
    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 15052 - 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 09960 - 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 09960 - 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 15211 - Ductile Iron Pipe: AWWA C151.
        a. Ascertain that polyethylene wrapping does not affect operation of valve.

## 2.05 STEAM VALVES

A. Valves in steam or steam condensate piping: Ductile iron body in accordance with ASTM A536, Grade 65-45-12 minimum or cast steel or forged steel.

## 2.06 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.

## 2.07 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 09960 - 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 01756 - 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 15111

# BALL VALVES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 15110 - 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 24.

B. American Water Works Association (AWWA):
   1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance in accordance with AWWA C507.
   2. Operation and maintenance manual.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

### 1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## PART 2 PRODUCTS

### 2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Unless otherwise indicated on the Drawings use:
   1. Metal body ball valves on metallic pipelines.
   2. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

### 2.02 METAL BODY BALL VALVES - FULL PORT (BAV00)

A. Metal Body Ball Valves, 6-Inch Size and Larger:
   1. Manufacturers: One of the following or equal:
      a. Crane ChemPharma Energy.
      b. DeZURIK/APCO.
      c. Henry Pratt Company.
   2. General:
      a. Type: Non-lubricated, resilient seated and capable of sealing in either flow direction.
      b. In accordance with AWWA C507.
      c. Stem packing: Manually adjustable while valve is under pressure.
      d. ASME B16.1, Class 125 flanged ends.
   3. Materials:
      a. Body: ASTM A48 cast iron and integrally cast bronze bushed trunnions.
      b. Ball: Type 304 or 316 stainless steel.
      c. Seats:
         1) Resilient seated valves:
            a) PTFE
      d. Stem seals: PTFE or Viton™.
   4. Valve actuator:
      a. Manually operated valves: Self-locking worm gear type actuator with position indicator. Permanently lubricate gearing. Provide adjustable screws to stop travel at both open and closed positions.
      b. Hydraulically operated valves: Provide hydraulic cylinder operator as specified in Section 13445A - Hydraulic and Pneumatic Cylinder Actuators.
      c. Electric motor operated valves: Provide electric motor operator as specified in Section 13447 - Electric Actuators.

B. Metal body ball valves, less than 6-inch size
   1. Manufacturers: One of the following, or equal:
      a. Conbraco Industries, Inc., Apollo Valves.
      b. Flow-Tek, Inc.
      c. Metso Automation/Jamesbury.
      d. NIBCO, Inc.
   2. General:
      a. Type: Non-lubricated, full port and capable of sealing in either direction.
      b. End connections:
         1) Threaded or solder ends for sizes 3-inch and smaller.

2) Class 150 flanged for sizes larger than 3 inches.
a) Flanges: In accordance with ASME B16.1 standards.
c. Stem packing: Manually adjustable while valve is under pressure.
d. Shafts:
1) Rigidly connected to the ball by a positive means.
a) Design connection to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
e. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
f. Temperature limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.
3. Materials:
a. Valves in copper lines: Bronze body.
b. Valves in steel and ductile iron piping: Ductile iron or cast steel body.
c. Valves in stainless steel piping: Stainless steel body, material type to match piping material as specified in Section 15052 - Common Work Results for General Piping.
d. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
e. Seats: PTFE.
f. Stem seals: PTFE or Viton™.
g. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
h. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) must be of fire safe design.

## 2.03 PLASTIC BODY BALL VALVES - FULL PORT (BAV40)

A. Manufacturers: One of the following or equal:
1. Asahi America.
2. Chemtrol Division, NIBCO, Inc.
3. Georg Fischer Piping Systems.
4. Hayward Flow Control.
5. IPEX USA, LLC
6. Plast-O-Matic Valves, Inc.

B. General:
1. Type: Non-lubricated and capable of sealing in either flow direction.
2. End connections:
a. 4 inches and smaller size: Socket end true unions for solvent welded connection to adjacent piping.
b. 6-inch size: Socket end true unions with attached flanges for flanged connection to adjacent piping.
3. All valves shall have integral ISO 5211 mounting pad for actuator installation.
4. All valves shall have integral plate for lock-out/tag-out.
5. Stem: Double O-ring seal with shear point above seal.
6. Pressure rating: Suitable for the test pressure and maximum temperature of the corresponding piping system listed in the Piping Schedule.

C. Materials:
   1. Body and ball:
      a. PVC piping systems: PVC.
      b. CPVC piping systems: CPVC.
   2. Seats: PTFE (Teflon™).
   3. O-rings: Match gasket material of corresponding piping system listed in the Piping Schedule.

D. Limit switches, when indicated on the Drawings:
   1. Mechanical cam type with watertight enclosure and suited for remote indication of valve open-close status.
   2. Mount on valve actuator.
   3. Contacts: 120-volt alternating current, 20 amperes at 75 to 100 percent power factor and 24-volt direct current, 5 amperes minimum.

E. Valve actuator:
   1. Valves shall be quarter turn operated with valve seat adjustability.
   2. Manually operated valves: Lever.
      Electric motor operated valves, when indicated on the Drawings: Provide electric motor operator as specified in Section 13447 - Electric Actuators.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

### 3.02 COMMISSIONING

A. As specified in Section 01756 - 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 15956 - Piping Systems Testing.

END OF SECTION

# SECTION 15116

# PLUG VALVES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Non-lubricated plug valves.
   2. Multi-port plug valves.

### 1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.
   2. C606 - Grooved and Shouldered Joints.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A536 - Standard Specification for Ductile Iron Castings.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and 15110 - Common Work Results for Valves.

A. Product data as defined in 01600 - Product Requirements.

B. Shop drawings showing installation arrangement of major component assemblies.

C. Calculations.

D. Vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.

E. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning:
      a. Interior coating.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

### 1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. As specified in Section 01600 - Product Requirements and Section 15110 - Common Work Results for Valves.

### 2.02 NON-LUBRICATED PLUG VALVES (PV00)

A. Manufacturers: One of the following or equal:
   1. DeZurik, "PEC".
   2. Clow Valve.
   3. Milliken Valve, Model 600/601.

B. Design:
   1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
   2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
      a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
      b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
   3. Compression washer: Provide flat compression washer made of Teflon ™, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
   5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
   6. Clearly mark valves to indicate their open and closed positions.
   7. Provide valves with ends as required by piping details indicated on the Drawings.
      a. Grooved end body valves:
         1) Usage: Plug valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints and as indicated on the Drawings.
         2) Grooved end joint design: In accordance with AWWA C606.

C. Materials:
   1. Body and plug: ASTM A126, Class B, cast-iron, with plug face of EPDM material suitable for the intended service as specified under paragraph "Design" above.
   2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8-inch on surfaces contacting the plug face.
   3. Stem bearing and bottom bearing: Type 316 stainless steel.
   4. Internal parts, except the body and plug: Type 316 stainless steel.
   5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

## 2.03 NON-LUBRICATED PLUG VALVES, FULL PORT (PV05)

A. Manufacturers: One of the following or equal:
   1. DeZurik, PEF.
   2. Clow Valve.
   3. Milliken, 601F/600F.

B. Design:
   1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
   2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
      a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
      b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
   3. Compression washer: Provide flat compression washer made of Teflon ™, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
   5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
   6. Clearly mark valves to indicate their open and closed positions.
   7. Provide valves with ends as required by piping details indicated on the Drawings.
      a. Grooved end body valves:
         1) Usage: Plug valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints and as indicated on the Drawings.
         2) Grooved end joint design: In accordance with AWWA C606.

C. Materials:
   1. Body and plug: ASTM A126, Class B, cast-iron, with plug face of EPDM material suitable for the intended service as specified under paragraph "Design" above.
   2. Body seats in valves 3-inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8-inch on surfaces contacting the plug face.
   3. Stem bearing and bottom bearing: Type 316 stainless steel.
   4. Internal parts, except the body and plug: Type 316 stainless steel.
   5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

## 2.04 MULTI-PORT PLUG VALVES FOR SLUDGE SERVICE (PV80)

A. Manufacturers: One of the following or equal:
   1. DeZurik, PTW, for 3-way valve, and PFW for 4-way valve.
   2. Milliken, equivalent product.

B. Design: Non-lubricated tapered plug type including plugs faced with neoprene, body of cast iron, and stainless steel bearings in the upper and lower journal areas.

C. Furnish valves with single, double, or transfer style plug as indicated on the Drawings or as required.

## 2.05 VALVE OPERATORS

A. Furnish valves with an operating wrench or worm gear operator:
   1. Equip valves 4-inch nominal size and smaller with a lever operator.
   2. Equip valves 6-inch nominal size and larger with a worm gear operator.

## 2.06 COATING

A. Coat and test interior metal surfaces as specified in Section 15110 - Common Work Results for Valves.

B. Field applied coating of valve exterior:
   1. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
      a. 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.
      b. 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.

## 2.07 SHIPMENT, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

# PART 3 EXECUTION

## 3.01 INSTALLATION

A. Install valves as specified in Section 15110 - Common Work Results for Valves and the manufacturer's instructions.
   1. Unless differently indicated on the Drawings install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.
   2. Install valves so that in the open position the plug is located in the top half of the valve body.

## 3.02 COMMISSIONING

A. As specified in Section 01756 - 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 15110 - Common Work Results for Valves.

END OF SECTION

## SECTION 15120

## PIPING SPECIALTIES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Piping specialties including:
   1. Flexible rubber connections.
   2. Bellows type expansion joints.
   3. Slip type expansion joints.
   4. Rubber expansion joints.
   5. Ball-type flexible joint pipe.
   6. Vibration control joints.
   7. Transition fittings.
   8. Pipe couplings for stainless steel piping.
   9. Pipe saddles.
   10. Tapping sleeves.
   11. Surge cushions.
   12. Sight glasses.
   13. Spray nozzles.
   14. Washdown monitors.
   15. Chemical Injector/Diffuser.

### 1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   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. A536 - Standard Specification for Ductile Iron Castings.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
   2. 372 - Drinking Water System Components - Lead Content.

## 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. For each piping 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.

D. Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning:
   1. Provide as specified in this Section.

## 1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

## 2.02 FLEXIBLE RUBBER CONNECTIONS

A. Manufacturers: One of the following or equal:
   1. Mercer Rubber Co., Type 150 Vibraflex.
   2. Red Valve Co., Inc., Part Number P-5.

B. Provide flexible rubber connections with 3/8-inch-thick neoprene or EPDM rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.

C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

## 2.03 BELLOWS TYPE EXPANSION JOINTS

A. Expansion joints for general service:
   1. Expansion joints: Flexible bellows type, or as otherwise specified or indicated on the Drawings.
   2. Manufacturers:
      a. Expansion joints: One of the following or equal:
         1) Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
         2) Flex-Weld, Inc., Keflex, Series 308.
         3) Victaulic, Depend-o-Lok, Omniflex stainless bellows expansion joint.
      b. Pipe alignment guides: One of the following or equal:
         1) Senior Flexonics Pathway, Inc.
         2) Flex-Weld, Inc.
      c. Intermediate supports: Provide with protective saddles. One of the following or equal:
         1) Unistrut Corporation, Roller-type.
         2) Bergen-Paterson Pipe Support Corp.
   3. Design:
      a. Expansion joint rating: 150 pounds per square inch gauge, at 300 degrees Fahrenheit.
      b. Bellows: Multi-ply (3 ply minimum) stainless steel, equipped with a self-draining liner guide.
      c. Axial travel of expansion joints: Not less than 1.50 inches.
      d. Ends: 150-pound ASME flanges, Victaulic, Depend-o-Lok Airmaster/Fluidmaster coupled ends, or plain suitable for welding connections, as required for piping in which installed.

B. Expansion joints for steam and hot water:
   1. Manufacturers: One of the following or equal:
      a. Flex-Weld, Inc., Keflex, Series 308-1215.
      b. Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
      c. Victaulic, Depend-o-Lok Omniflex Expansion Joint.
   2. Design:
      a. Single reinforced bellows type or Victaulic mechanical couplings.
      b. Pressure and temperature ratings: 150 pounds per square inch gauge, and 500 degrees Fahrenheit service.
      c. Bellows: Multi-ply (3 ply minimum) Type 321 stainless steel, equipped with a Type 321 stainless steel liner.
      d. Axial travel of expansion joints: 3 inches minimum.
      e. Ends: 150-pound ASME flanges.

C. Copper piping expansion joints:
   1. Expansion joints for copper pipe: As specified before, except externally guided, and provide for 3-1/4-inch expansion per 100 feet of piping.

D. Roof drain expansion joints:
   1. Neoprene bellows between roof drain fitting and drain piping.
   2. Up to 12-inch static head.
   3. Complete with Type 316 stainless steel clamps.
   4. Manufacturers: One of the following or equal:
      a. Watts, Model RD-900.

b. Flexicraft Industries, DWV.

## 2.04 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Flexible hose:
   1. General:
      a. Type: Flexible stainless steel hose.
         1) Unbraided for pressures up to 150 pounds per square inch.
         2) Single braided for pressures up to 225 pounds per square inch.
         3) Double braided for pressures up to 360 pounds per square inch.
      b. End connections: Flanged, or as needed to comply with the specified type of joint:
         1) Sizes 2-1/2 inches and smaller may have threaded nipples.
         2) Sizes 2 inches through 12 inches may have grooved ends.
   2. Design:
      a. Open pitch spacing of corrugation.
      b. 1 fixed and 1 floating raised face flanged end connection.
      c. Able to withstand up to 1-inch offset motion from centerline.
   3. Materials:
      a. Hose: Type 316 stainless steel.
      b. Flanges: Carbon steel.

## 2.05 TRANSITION FITTINGS

A. Manufacturers: One of the following or equal:
   1. Spears.

B. Materials:
   1. Slip socket: Schedule 80 PVC.
   2. Collar: Type 316 stainless steel.
   3. Threaded insert: Type 316 stainless steel.

## 2.06 PIPE SADDLES

A. For ductile iron pipe:
   1. Double strap brass type.
   2. Manufacturers: One of the following or equal:
      a. A.Y. McDonald, Style 3825
      b. The Ford Meter Box Company, Style 202B
      c. Mueller Company, Style BR2B.
   3. Materials:
      a. Pipe saddle body, straps, and nuts: Brass or silicon bronze.
      b. Gaskets: Rubber or EPDM.

B. For PVC C900 or C905 pipe:
   1. Manufacturers: One of the following or equal:
      a. Smith-Blair, Inc., Style 317.
      b. Romac Industries, Inc., Style 202S.
   2. Materials:
      a. Pipe saddles: Ductile iron with fusion bonded epoxy finish.

b. Straps, bolts, and nuts: Type 304 stainless steel with Teflon™ coating on nuts.
c. Gaskets: Rubber or EPDM.

## 2.07 TAPPING SLEEVES

A. Manufacturers: One of the following or equal:
1. Smith-Blair, Inc., Style 622.
2. Romac Industries, Inc., Style FTS 420.

B. Materials:
1. Tapping sleeves: Steel construction.
2. Bolts and nuts: Type 304 stainless steel.
3. Nuts: Teflon™ coated.
4. Gaskets: Rubber or EPDM.
5. Size of tapped boss: As indicated on the Drawings.

## 2.08 SIGHT GLASSES

A. Assembly: Body casting with ASME standard adapter flanges, borosilicate Pyrex™ glass section, cleaning assembly with scalloped neoprene wipers, operating rod and handle, packing gland with packing and suitable adapter, and cock with solvent hand pump.

B. Suitable for a minimum pressure of 30 pounds per square inch gauge.

C. Manufacturers: One of the following or equal:
1. EIMCO Process Machinery Division of Envirotech Corp.
2. Ernst Flow Industries, Type K2 or K3 Cleanable Sight Glass.

## 2.09 SPRAY NOZZLES

A. Design:
1. Operating pressure 10 pounds per square inch gauge, at which pressure each nozzle discharges not less than 3.5 gallons per minute, nor more than 5.0 gallons per minute.
a. Spray: Flat, heavy sheet, fan with uniform distribution.
b. Fan width at the water surface not less than 6.5 feet at 10 pounds per square inch gauge.
c. Spray deflection with a replaceable deflector insert free to rotate away from the orifice opening and mechanically locked in place and counterweighted.
2. Spray nozzles structurally suitable for pressure up to 200 pounds per square inch gauge.
3. Nozzles, easy flush type.

B. Materials:
1. Spray nozzles: Leaded bronze.
2. Nozzles provided with 1/4-inch national pipe thread, and the orifice diameter not less than 1/4 inch.
3. Replaceable spray deflector: Neoprene rubber.

## 2.10 SHIPPING

A. As specified in Section 01600 - Product Requirements.

# PART 3 EXECUTION

## 3.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Drawings supersede conflicts with this Section.

C. Bellows type expansion joints and vibration control joints:
   1. Protect joints against damage during pressure test.

## 3.02 INSTALLATION

A. Expansion control joints:
   1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
   2. Install bellows type expansion joints so as to allow 2-1/4-inch expansion per 100 linear feet of piping.
   3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
      a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
   4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
   5. Provide control rods and additional guides where indicated on the Drawings, but at no greater intervals than recommended by the joint manufacturer in published instructions.
   6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.

B. Bellows type expansion joints for steam and hot water:
   1. Install not less than 1 expansion joint in a run of steam or hot water piping which exceeds 20 feet in length.
      a. Do not exceed 150 feet spacing of expansion for steam piping and 200 feet for hot water piping.
   2. Where possible, install expansion joints adjacent to an anchor; provide piping with 2 concentric guides, the first being within 2 feet of the end of the joint opposite the anchor.
   3. At expansion joints not installed adjacent to an anchor, provide 2 concentric guides on piping within 2 feet off both ends of the expansion joint.
   4. Lock expansion joint against movement until pressure test is completed.

C. Transition couplings:
   1. Application:
      a. Use transition couplings with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
   2. Install transition-coupling products specifically designed and manufactured for that application.

D. Pipe saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

E. Tapping sleeves:
   1. Verify existing pipe material and outer diameter prior to ordering materials.
   2. Coat threads on bolts with anti-gall coating prior to installation.

F. Spray nozzles:
   1. Install spray nozzles so that elevation of the nozzles is 18 inches above the water surface.

## 3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Required only for:
      a. Transition couplings.
      b. Tapping sleeves for large diameter pipe.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.
   3. Provide Manufacturer's Representative Onsite:
      a. Installation: 2 trips,1 day each:
         1) Installation consultation and advice.
         2) Installation inspection.

C. Field testing:
   1. As specified in Section 15052 - Common Work Results for General Piping.
   2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION

## SECTION 15121

## 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. 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.

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 01330 - 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 specified in Section 01783 - Warranties and Bonds.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. As specified in Section 01600 - 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 01756 - 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: Neoprene rubber, Buna-N or EPDM.

F. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Tapecoat Co., Inc., T.C. Mastic.
      b. Kop-Coat Co., Inc., Bitumastic Number 50.
   2. Thickness: Minimum 0.040 inch.

### 2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style DJ400.
      b. Smith-Blair, Inc., Series 975.
   2. Materials:
      a. Flanged spool: AWWA C207 steel pipe:
         1) ASTM A53 for sizes 3 inches to 12 inches.
         2) ASTM A36 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36 or A53.
      c. Follower ring: Ductile iron in accordance with ASTM A536.
      d. 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.
      e. Tie rods: High tensile steel in accordance with ASTM A193 Grade B7.
   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.

B. Flanged coupling adapters: 12-inch size and smaller:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 227.
      b. Romac Ind., Inc., Style FCA501.
      c. Smith-Blair, Inc., Series 912.
   2. Materials:
      a. Flanged body: Ductile iron in accordance with ASTM A536.
      b. Follower ring: Ductile iron in accordance with ASTM A536.
      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.

C. Flanged coupling adapters: Greater than 12-inch size:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
      b. Romac Ind., Inc., Style FC400.
      c. Smith-Blair, Inc., Series 913.
   2. Materials:
      a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      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.

D. Flexible couplings:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 253.
      b. Romac Ind., Inc., Style 501.
      c. Smith-Blair, Inc., Series 441.
   2. Materials:
      a. Center rings: Ductile iron in accordance with ASTM A536.
      b. Follower rings: Ductile iron in accordance with ASTM A536.

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 in accordance with ASTM F593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

| Nominal Pipe Size | Sleeve Length |
|---|---|
| 3 inch and smaller | Manufacturer's standard |
| 4 inch through 8 inch | 7 inches |
| 10 inch through 14 inch | 12 inches |
| Greater than 16 inch | Use steel flexible coupling per Pipe Couplings for Steel Piping |

E. Flexible couplings (Gravity Flow):
1. Manufacturers: One of the following or equal:
    a. Fernco Flexible Coupling.
2. Materials:
    a. In accordance with ASTM D5926, C1173 and applicable portions of ASTM C443, C425, C564, and D1869.
3. Requirements:
    a. In underground and underwater installations, couplings shall be corrosion resistant or coated with a fusion applied epoxy coating in accordance with AWWA C213.
    b. Bolts and hardware shall be stainless steel 18-8 type 316 epoxy coated alloy hardware.

F. 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.

G. 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 09960 - 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.

## 2.03 PIPE COUPLINGS FOR CARBON STEEL PIPING

A. Dismantling joints:
1. Manufacturers: One of the following or equal:
a. Romac Ind., Inc., Style DJ400.
b. Smith-Blair, Inc., Series 975.
2. Materials:
a. Flanged spool:
1) C207 Schedule 40 pipe in accordance with ASTM A53 for sizes 3 inches to 12 inches.
2) Steel for pipe in accordance with ASTM A36 or A53 for sizes 14 inches to 72 inches.
b. End ring and body:
1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36.
c. Follower ring: Ductile iron in accordance with ASTM A536 or steel in accordance with ASTM A36 or A576.
d. 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.
e. Tie rods: High tensile steel in accordance with ASTM A193 grade B7.
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: Fusion bonded epoxy certified in accordance with NSF 61.

B. Flanged coupling adapters:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
      b. Romac Ind., Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).
      c. Smith-Blair, Inc., Series 913.
   2. Materials:
      a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      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.

C. Flexible couplings:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 38.
      b. Smith-Blair, Inc., Series 411.
      c. Romac Ind., Inc., Style 511 or Style 400.
   2. Materials:
      a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
      b. 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. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
   4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

| Nominal Pipe Diameter | Sleeve Length |
|---|---|
| 2-1/2 inch and smaller | Manufacturer's standard |
| 3 inch through 6 inch | 7 inch |
| 8 inch through 14 inch | 7 inch |
| Greater than 14 inches | 10 inch |

D. Restrained flange coupling adapters:
   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 an apply forces evenly.
        3) Restraining bolts: Ductile iron in accordance with ASTM A536. 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 certified in accordance with NSF 61.

E. Grooved joint couplings:
1. Model numbers from one manufacturer are shown to indicate type only. Equivalent products of other manufacturers may be submitted for approval.
2. Coating: As specified in Section 09960 - High-Performance Coatings.
3. Sizes through 12 inch:
    a. Rigid type:
        1) Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
        2) 2 inch through 6 inch: Installation-ready, for direct stab installation without field disassembly, with grade EHP gasket rated to plus 250 degrees Fahrenheit.
        3) Manufacturers: One of the following or equal:
            a) Victaulic Style 107.
            b) Victaulic Zero-Flex Style 07.
    b. Flexible type:
        1) For use in locations where vibration attenuation and stress relief are required.
        2) Three flexible couplings may be used in lieu of a flexible connector.
        3) The couplings shall be placed in close proximity to the source of the vibration.
        4) Manufacturers: The following or equal:
            a) Victaulic Style 77.
    c. Flange adapter:
        1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
        2) Manufacturers: The following or equal:
            a) Victaulic Style 741.
4. Sizes 14 inch through 24 inch:
    a. Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket.

b. Rigid type:
    1) Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.
    2) Manufacturers: The following or equal:
        a) Victaulic Style W07.
c. Flexible type:
    1) Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.
    2) Manufacturers: The following or equal:
        a) Victaulic Style W77.
d. Flange adapter:
    1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
    2) Manufacturers: The following or equal:
        a) Victaulic Style W741.

5. For sizes 30 inch and larger:
    a. Manufacturers: The following or equal:
        1) Victaulic Style AGS multiple-segment housing may be used.

## 2.04 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Flexible couplings:
    1. Manufacturers: The following or equal:
        a. Dresser, Inc., Style 38.

B. Grooved joint couplings:
    1. Manufacturers: The following or equal:
        a. Victaulic Co.
    2. Materials:
        a. Housings:
            1) Ductile iron in accordance with ASTM A536.
            2) Stainless steel in accordance with ASTM A351.
        b. Gasket: Elastomer in accordance with ASTM D2000.
        c. Bolts and nuts:
            1) Electroplated steel in accordance with ASTM A449.
            2) Stainless steel in accordance with ASTM F593.
    3. Rigid type:
        a. Victaulic Style 89 and W89 (ductile iron housings).
        b. Victaulic Style 489 (stainless steel housings).
    4. Flexible type: Victaulic Style 77S.

# PART 3 EXECUTION

## 3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with 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 15052 - 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.

F. Bolted, split-sleeve couplings:
   1. Inspect each coupling to ensure that there are no damaged portions of the coupling.
      a. Pay particular attention to the sealing pad/sealing plate area.
      b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all times.
   2. Wrenches:
      a. Conform to manufacturer instructions.
      b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
      c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
   3. No joint shall be misfit in any plane.
   4. On the fixed ends of bolted, split-sleeve couplings, the shoulders shall bear on the restraint rings all around with no visible gap.
   5. Ends of piping where coupler are installed shall be smooth and free of defects.
      a. Remove weld splatter and grind smooth.
      b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION

## SECTION 15211

## DUCTILE IRON PIPE: AWWA C151

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Ductile iron pipe, joints, connections, fittings, and pipe linings and coatings.

B. As specified in Section 15052 - 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. 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 01330 - 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 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. Calculations for 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 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. The length of pipe that must be restrained on each side of the focus of a thrust load as indicated on the Drawings or specified in the Pipe Schedule.

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 Contractor.

## 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 15052 - 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 15052 - Common Work Results for General Piping.

e. Gaskets:
    1) Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052 - Common Work Results for General Piping.

2. Grooved joints:
    a. In accordance with AWWA C606, as complemented and modified below, radius-cut type.
    b. Couplings:
        1) Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12.
    c. Bolts and nuts:
        1) As specified in Section 15052 - Common Work Results for General Piping.
    d. Gaskets:
        1) As specified in Section 15052 - Common Work Results for General Piping.
    e. Fittings:
        1) In accordance with AWWA C606, rigid radius-cut groove:
        2) Center-to-center dimensions: In accordance with AWWA C110.
        3) Wall thickness and other characteristics: In accordance with AWWA C606.
    f. Flanged unit connections:
        1) Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.
3. Mechanical joints:
    a. In accordance with AWWA C111.
    b. Gaskets:
        1) As specified in Section 15052 - Common Work Results for General Piping.
    c. Bolts and nuts, including T-bolts:
        1) As specified in Section 15052 - Common Work Results for General Piping.
4. Push-on rubber gasket joints:
    a. In accordance with AWWA C111.
    b. Gaskets:
        1) As specified in Section 15052 - Common Work Results for General Piping.
5. Integrally restrained mechanical joints:
    a. Manufacturers: Where restrained mechanical joints are required, use one of the following or equal:
        1) American Cast Iron Pipe Co., MJ Coupled Joint.
        2) U.S. Pipe, Bolt-Lok.
        3) U.S. Pipe, Mech-Lok.
    b. Application:
        1) Where designated mechanical restraint.
        2) Mechanical joint is specified in the Piping Schedule as indicated on the Drawings. Supply a restrained mechanical joint piping system, which includes restrained mechanical joints where necessary based upon thrust calculations.

3) Standard mechanical joints as specified above can be used where thrust calculations demonstrate restraint is not required.

c. Design:
1) Integral retainer weldment type or lugged type joint with Type 304 stainless steel rods and nuts.
2) Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.

d. Gaskets:
1) As specified in Section 15052 - Common Work Results for General Piping.

e. Bolts and nuts, including T-bolts:
1) As specified in Section 15052 - Common Work Results for General Piping.

6. Integrally restrained push-on joints:

a. Application:
1) Where designation restrained push-on is specified in the Piping Schedule provided in Drawings or as indicated on the Drawings, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.

b. Design:
1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
2) Suitable for the following working pressures:
a) For 4- through 24-inch pipe: 350 pounds per square inch gauge.
b) For 30- through 54-inch pipe: 250 pounds per square inch gauge.

c. Gaskets:
1) As specified in Section 15052 - Common Work Results for General Piping.

d. Manufacturers: One of the following or equal:
1) U.S. Pipe, TR Flex.
2) McWane Ductile, TR Flex.
3) American Cast Iron Pipe Co., Flex Ring or Lok-Ring.

e. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

C. Connections:

1. Tapping saddle as specified in Owner standard specification.
a. If Owner does not have a standard specification, provide tapping saddles as specified in Section 15120 - Piping Specialties.

2. Tapping sleeve as specified in Owner standard specification.
a. If Owner does not have a standard specification, provide tapping sleeves as specified in Section 15120 - Piping Specialties.

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 15052 - Common Work Results for General Piping.
   3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

## 2.05 ASPHALT VARNISH

A. Coating:
   1. Factory apply.

B. Primer:
   1. Factory applied for field coating.

C. Compatible with materials as specified in Section 09960 - High-Performance Coatings.

## 2.06 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 II.

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 lining 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 gage spaced at maximum 1-inch centers.
        2) No. 14 gage steel wire at maximum 1/2-inch centers.

## 2.07 CERAMIC EPOXY

A. Line pipe with ceramic epoxy.

B. Manufacturers: One of the following or equal:
1. PROTECTO 401.
2. SP-2000W.

C. Material:
1. Amine cured Novolac epoxy containing at least 20 percent by volume of ceramic quartz pigment.

D. Application:
1. The lining shall only be applied by a manufacturer-authorized representative with no less than 5 years of experience in applying the specified material.
2. The application of the lining shall be performed in accordance with manufacturer's published specifications.
3. Pipe and fittings shall be delivered to application facility with no interior lining.
4. Interior of pipe shall be abrasive blasted in accordance with manufacturer instructions.
5. Apply lining in accordance with manufacturer instructions.
6. Minimum dry film thickness (DFT): 40 mills.

E. Coverage:
1. Gasket and spigot ends on joints:
    a. Minimum coverage using joint compound: 6 mils.
    b. Maximum coverage using joint compound: 10 mils.
2. Mechanical joints:
    a. Extend lining from spigot end to edge of gauging ring.
3. Number of coats:
    a. In accordance with manufacturer instructions.

F. Source quality control:
1. Test pipe and fitting lining with a magnetic film thickness gauge in accordance with SSPC PA-2 Film Thickness Rating.
2. Test lining integrity of pipes in accordance with coating manufacturer instructions using a holiday detection testing instrument set at the specified voltage.
3. Discard pipe or reline pipe when pinholes or discontinuities are found.
4. Repair holidays with joint compound in accordance with coating manufacturer instructions and re-test.

## 2.08 GLASS LINING

A. Manufacturers: One of the following or equal, having a minimum of 5 years of experience supplying this product to the wastewater and water industry:
   1. Water Works Manufacturing, Ferrock MEH-32 Lining.
   2. Vitco Corp., SG-14 Lining.

B. Material:
   1. Special glasses and inorganic materials suited for lining of sewage, sludge, and scum piping.
   2. Thickness: 0.008 to 0.012 inch.
   3. Hardness: 5 to 6 on the Mohs Scale.
   4. Density: 2.5 to 3.0 grams per cubic centimeter, measured in accordance with ASTM D792.
   5. Thermal shock resistance: Capable of withstanding 350 degrees Fahrenheit change from 430 degrees Fahrenheit to 80 degrees Fahrenheit without crazing, blistering, or spalling.
   6. Gloss retention: Capable of retaining gloss after immersion in an 8 percent sulfuric acid solution at 148 degrees Fahrenheit for 10 minutes.
   7. Weight loss: Maximum 3 milligrams per square inch when tested in accordance with ASTM C283.

C. Fabrication:
   1. Use piping that is suitable for glass lining with minimum Class 53 wall thickness after application of glass lining.
   2. Machine interior of pipe.
      a. Bore or grit blast in accordance with NAPF 500-03 prior to application of glass lining.
   3. Screw factory assembled flanges on pipe, align boltholes, and flange faces, unless otherwise specified.
   4. Apply lining to surfaces free of chemicals.
   5. Place piping in furnaces specially designed for heating piping until glass melts and fuses with an integral molecular bond to the base metal.
   6. Test 100 percent of the product in the factory in accordance with ASTM B1000.

## 2.09 POLYETHYLENE ENCASEMENT

A. General:
   1. Polyethylene encasement shall be supplied by the pipe manufacturer.

B. Materials: Supply one of the following polyethylene encasements:
   1. Two layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or,
   2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
   3. Single layer of V-Bio® enhanced polyethylene encasement (3 layers of coextruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

## 2.10 PLURAL COMPONENT POLYURETHANE

A. Line pipe with plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.

B. Manufacturers: One of the following or equal:
   1. Chemline, Chemthane 2265.
   2. Lifelast, Equivalent product.

C. Surface preparation:
   1. In accordance with AWWA C222 and as specified in this Section.
   2. In accordance with SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer's requirements, whichever is greater.

D. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever is happens first.
      d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
      e. Base adhesion testing on 3 tests.
         1) Conduct the tests by the same person, test equipment, and test procedure.
         2) Complete the tests within a 30-minute period.
      f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
      g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
   2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
      a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
   3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
      a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
   4. Epoxy coating and lining adhesion criteria:
      a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.

b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.

5. Pipe lot performance criteria:
   a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
   b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
      1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
   a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
   b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
   c. Adhesion test failure:
      1) Adhesive or substrate failure.
         a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
      2) Cohesive test failure.
         a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
   d. Retest coating adhesion tests:
      1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
      2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
      3) Retest disputed adhesion tests.
         a) Owner's representative will witness dolly attachment and adhesion retesting.
   e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
   f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
      1) Pipe identification.
      2) Pipe coating date.
      3) Adhesion test date.
      4) Surface tested (interior or exterior).
      5) Surface temperature at time of test.
      6) Coating thickness.
      7) Tensile force applied.
      8) Applied load rate per second.
      9) Mode of failure.
      10) Percentage of failure types, previously defined, relative to dolly surface area.
      11) Dolly size and attachment glue used.
      12) If different coatings are tested, include coating manufacturer and product number.
7. Adhesion test repairs:
   a. Fabricator or contractor to complete adhesion repairs as specified this Section.

b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

E. Long term adhesion test:
   1. Acceptance criteria:
      a. Not more than 10 percent loss of adhesion over duration of test.
      b. Differential based on the highest average adhesion result to the lowest average adhesion result.
   2. Test durations, cumulative:
      a. 1 day.
      b. 7 days.
      c. 3 weeks.
      d. 2 months.
   3. Sample preparation:
      a. SSPC-SP 5, 3.00 mils profile, minimum.
      b. Test area minimum: 18-inches by 18-inches.
      c. Curved steel plate.
         1) Minimum radius of 15-inches.
         2) Inclined between 30 and 45 degrees.
   4. Test procedure:
      a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
   5. Adhesion test results:
      a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
      b. Based an average of the 5 highest pulls and identify the values used.
   6. Record adhesion pulls and their failure mode.
   7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

## 2.11 SEAL COAT

A. Asphaltic seal coat:
   1. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating.
   2. Apply in accordance with AWWA C151.

# PART 3 EXECUTION

## 3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 15052 - Common Work Results for General Piping.
   2. For underground piping, the trenching, backfill, and compaction:
      a. Inspect coating prior to backfill.
      b. As specified in Section 02318 - Trenching.

B. Joints:
   1. Install types of joints as specified in the piping schedule provided in Section 15052 - 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 15052 - 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. The 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.

## 3.02 DEFECTS IN COATINGS EXCEPT TAPE WRAP AND CEMENT MORTAR COATING

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
    1. Pipe joints exceeding the following defect maximum will be rejected.
        a. Minor defects:
            1) No more than 1.5 per 100 square feet of surface area.
            2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
            3) Repairs for adhesion testing will not be included in the total number of repairs.
            4) Repair in accordance with manufacturer's requirements.
        b. Major defects:
            1) No more than 3 major repairs on each pipe joint.
            2) No more than 30 percent repairs on the pipe surface area with defects.
    2. Minor repairs:
        a. Repairs less than 8-inches in the greatest dimension.
        b. Repair in accordance with manufacturer's requirements.
    3. Major repairs:
        a. Repairs that exceed 8-inches in the greatest dimension.
        b. Repair in accordance with manufacturer's requirements.

## 3.03 PLURAL COMPONENT POLYURETHANE

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining.
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

## 3.04 POLYETHYLENE ENCASEMENT

A. Wrap buried ductile iron pipe and fittings in 2 layers of loose low-density polyethylene wrap or a single layer of high-density polyethylene wrap in accordance with AWWA C105 and as specified in this Section.

B. Wrap polyethylene encasement to be continuous and terminated neatly at connections to below grade equipment or structures.

C. At wall penetrations, extend encasement to the wall and neatly terminate.

D. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.

E. When rising vertically in unimproved areas, extend encasement on pipe 6 inches above existing grade and neatly terminate.

F. Repair tears and make joints with 2 layers of plastic tape.

G. Work shall be inspected prior to backfilling of pipe and associated items.

## 3.05 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
   1. Test as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

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.

C. Verify that interior surfaces of ceramic epoxy and glass lined pipe and fittings have continuous coverage:
   1. Test random samples, as directed by Engineer, in accordance with ASTM B1000.
   2. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

## SECTION 15230

## PLASTIC PIPING AND TUBING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Plastic pipe, tubing, and fittings for systems that are not plumbing systems.

### 1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.12 - Cast Iron Threaded Drainage Fittings.

B. ASTM International (ASTM):
   1. D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
   2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
   5. D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated (SDR Series)**.**
   6. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   7. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   8. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   9. D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
   10. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   11. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
   12. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
   13. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   14. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   15. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   16. D3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.

17. D4101 - Standard Specification for Polypropylene Injection and Extrusion Materials.
18. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
19. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
20. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
21. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
22. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
23. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
24. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
25. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. American Water Works Association (AWWA):
   1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches, for Water Transmission Distribution.

D. NSF International (NSF).

E. Plastics Pipe Institute (PPI):
   1. TR 31 - Underground Installation of Polyolefin Piping.

## 1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. CPVC: Chlorinated polyvinyl chloride.

C. DR: Dimension ratio.

D. DWV: Drain, waste, and vent.

E. HDPE: High-density polyethylene.

F. ID: Inside diameter of piping or tubing.

G. NPS: Nominal pipe size followed by the size designation.

H. NS: Nominal size of piping or tubing.

I. PE: Polyethylene.

J. PP: Polypropylene.

K. PVC: Polyvinyl chloride.

L. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

## 1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.
   3. Polyethylene pipe submittals: Include:
      a. Installation equipment including details on fusion machine used to join polyethylene pipe sections.
      b. Qualifications of installation crew for use of the fusion machine used for joining polyethylene pipe.

## 1.05 QUALITY ASSURANCE

A. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.

B. Fusion machine technician qualifications: 1-year experience in the installation of similar PE piping systems from the same manufacturer.

C. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

# PART 2 PRODUCTS

## 2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft neoprene gasket.

## 2.02 PVC PIPING, SCHEDULE TYPE

A. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings or Pipe Schedule.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
      c. DWV fittings: In accordance with ASTM D2665.
   3. Solvent cement: In accordance with ASTM D2564:
      a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp., Type P70.
         2) Cement: IPS Corp., Type 724 cement or another cement certified by the manufacturer for chemical service.

## 2.03 PVC PIPING, CLASS TYPE

A. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. PVC pipe, Class Type: In accordance with ASTM D2241:
   1. Thermoplastic pipe materials designation code: PVC 1120, 1220, or 2120.
   2. PVC compound: Class 12454 in accordance with ASTM D1784.
   3. Standard dimension ratio: SDR not greater than 17 unless otherwise noted.

C. Fittings: Ductile iron with transition gasket sized to accommodate the outside pipe diameter.

D. PVC pipe, Class Type: In accordance with AWWA C900:
   1. Pressure Class: as scheduled in Section 15052 - Common Work Results for General Piping.
   2. Fittings: Cast or ductile iron fittings as specified in Section 15211 - Ductile Iron Pipe: AWWA C151, sized for the dimensions of the pipe being used.
   3. Joint design: Push-on or mechanical joint type as identified in Piping Schedule.
   4. Gaskets: Neoprene in accordance with ASTM D1869 or ASTM F477.

## 2.04 PVC GRAVITY SEWER PIPING

A. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Materials:
   1. Polyvinyl chloride (PVC) gravity sewer pipe and fittings: In accordance with ASTM D3034 for piping NPS 15 and smaller diameter, and to ASTM F679 for piping NPS 18 and larger diameter:
      a. Referenced standards apply as complemented and modified in this Section.
      b. Fittings: Supplied by the pipe manufacturer.
   2. PVC compounds: Class Number 12454, in accordance with ASTM D1784:
      a. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers: Not to exceed 10 parts by weight per 100 of PVC resin in the compound.
   3. Pipe NPS 15 and smaller diameter: Wall thickness SDR 26:
      a. Joints: Push-on joints in accordance with ASTM D3212.
   4. Pipe NPS 18 and larger diameter:
      a. PVC compound: Cell classification 12454 in accordance with ASTM D1784.
      b. Minimum wall thickness: Thickness T-1 in accordance with Table 1 in ASTM F679.
      c. Joints: Integral bell gasketed joints in accordance with ASTM F679.
      d. Bell: Fabricated from pipe sections, thickness of the wall of the bell equivalent to the pipe wall thickness.
      e. Gasket ring: Locked into the bell.
      f. Spigot end of the pipe: Marked by the manufacturer to identify the final in-place position of the spigot in the bell.
   5. Fittings, including wyes, tees, elbow caps, plug adapters, and manhole waterstops: Same wall thickness as the pipe:
      a. Fittings: Factory molded with joints and gaskets equal to those of the pipe.
   6. Gasket: Neoprene in accordance with ASTM D3212 or ASTM F477:
      a. Keep rubber gasket in place during pipe joining.
   7. Gasket for connection to manhole: Stainless steel clamp with gasket or similar device to seal the penetration.

## 2.05 CPVC PIPING

A. Materials:
   1. CPVC pipe: Schedule 40 or Schedule 80, as specified, in accordance with ASTM F441 and Appendix, CPVC 4120:
      a. Pipe: Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D1784.
      b. Manufacturers: One of the following or equal:
         1) Charlotte Pipe and Foundry Co.
         2) Eslon Thermoplastics, Inc.
         3) GF Harvel.
   2. Fittings: In accordance with ASTM F438 or ASTM F439 for pressure fittings, as appropriate to the service and pressure requirement:
      a. Fittings: Supplied by the pipe manufacturer.
      b. Manufacturers: One of the following or equal:
         1) Colonial Engineering.
         2) Eslon Thermoplastics, Inc.
         3) Chemtrol.
         4) Spears Manufacturing Co.

3. Solvent cement: In accordance with ASTM F493:
    a. For CPVC pipe in chemical service, utilize IPS Corp., Type 724 cement or another cement certified by the manufacturer for high strength hypochlorite service.

## 2.06 PP PIPING

A. The requirements for PP piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Materials:
    1. Pipe: Schedule 40 dimensions, extruded from Type I-19509 material in accordance with ASTM D4101.
    2. Fittings: Molded from the same material and same laying length in accordance with ASME B 16.12:
        a. Fittings: Manufactured by pipe manufacturer.

## 2.07 PE TUBING AND FITTINGS

A. Materials:
    1. Small bore PE tubing: Black flexible virgin PE tubing, OD copper tubing size.
        a. Plastic tubing ID as follows:
            1) For NS 1/4 inch, ID of 0.170 inch.
            2) For NS 5/16 inch, ID of 0.187 inch.
            3) For NS 3/8 inch, ID of 0.251 inch.
            4) For NS of 1/2 inch, an ID of 0.375 inch.
    2. Fittings: Compression fittings, Dekoron E-Z; or equal.
    3. Protective sheath:
        a. Manufacturers: One of the following or equal:
            1) Dekoron, "Poly-Cor."
            2) Parker Hannifin Corp./Fluid connector Products, Parflex Division, Multitube.
    4. Plug-in fittings for connection to instruments: Brass quick-connect fittings.

## 2.08 PE PIPING FOR UNDERGROUND GAS DISTRIBUTION

A. Manufacturers: One of the following or equal:
    1. DuPont.
    2. Amsted Industries Inc., Plexco.

B. Manufactured in accordance with ASTM D2513 using a compound in accordance with ASTM D1248, PE 2306/2406:
    1. SDR: Maximum of 11.

C. Fittings: In accordance with ASTM D2513 for socked fusion joints, and ASTM D3261 for butt fusion joints.

## 2.09 PE PIPING FOR DRAIN, WASTE, AND VENT PIPING SYSTEMS

A. General:
    1. Pipe and fittings: High-density polyethylene.

2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F714:
    a. SDR: Maximum of 11.

B. Manufacturers: One of the following or equal:
    1. DuPont, Sclairpipe.
    2. Polaris, Duratuff; or equal.

C. Pipe, fittings, and adapters: Furnished by the same manufacturer, and compatible with components in the same system and with components of other systems to which connected.

D. Materials:
    1. Polyethylene: In accordance with ASTM D1248, Type III, Class C, Category 5, Grade P34; listed by the Plastic Pipe Institute under the designation PE 3408; and have a minimum cell classification, in accordance with ASTM D3350.
    2. Pipe and fittings: Manufactured from material with the same cell classification.

## 2.10 CORRUGATED HDPE FOR STORM DRAIN

A. General
    1. Pipe and fittings: corrugated high-density polyethylene in accordance with ASTM F2648.

B. Materials
    1. Material for pipe production shall meet the requirements of ASTM D3350.

C. Joint Performance:
    1. Pipe shall be joined using a bell and spigot joint meeting ASTM F2648. The joint shall be soil-tight and shall use gaskets. The gaskets shall meet ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. A joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.

D. Fittings:
    1. Fittings shall conform to ASTM F2306.
    2. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the soil-tight joint performance requirements of ASTM F2306.

E. Manufacturers:
    1. One of the following or equal:
        a. ADS, N-12.
        b. JM Eagle, Eagle Corr PE.

## 2.11 CORRUGATED HDPE FOR ODOR CONTROL

A. General:
   1. Pipe and fittings: corrugated high-density polyethylene.
      a. 12-inch to 30-inch dual wall pipe with smooth interior and annular exterior corrugations in accordance with ASTM F2736
      b. 30-inch to 60-inch triple wall pipe with smooth interior and exterior surfaces with annular inner corrugations in accordance with ASTM F2764
      c. Pipe stiffness shall be a minimum of 46 pii when tested in accordance with ASTM D2412.

B. Materials:
   1. Material for pipe production shall meet the requirements of ASTM D3350.

C. Joint Performance:
   1. Pipe shall be joined with a gasketed integral bell and spigot joint meeting the requirements of ASTM F2736 and ASTM F2764, for the respective diameters.
   2. Pipe joints shall be watertight according to the requirements of ASTM D3212. Gaskets shall meet requirements of ASTM F447. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. Spigot shall be designed to accept 2 gaskets which can be fully inserted into the bell. A joint lubricant from the manufacturer shall be used on the gasket and bell during assembly.

D. Fittings:
   1. Shall conform to ASTM F2736 and ASTM F2764.
   2. Bell and spigot connections shall utilize a welded or integral bell and spigot with gaskets meeting ASMT F477.
   3. Fittings shall be fabricated from the same materials as the pipe and be from the same manufacturer as the pipe.

E. Manufacturers:
   1. One of the following or equal:
      a. ADS, Sanitite.

## 2.12 SOURCE QUALITY CONTROL

A. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. PVC piping, Schedule Type:
   1. Mark pipe and fittings in accordance with ASTM D1785.

C. PVC piping, Class Type:
   1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, two times the pressure class of the pipe for a minimum of 5 seconds.

D. PVC gravity sewer piping:
   1. Mark pipe and fittings in accordance with ASTM D3034. Also mark the production control code on pipe and fittings.

E. CPVC piping:
   1. Mark pipe and fittings in accordance with ASTM F441.

F. PP piping:
   1. The requirements for PP piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
   2. Test samples and testing: Cut test samples of pipe, 6 inches long, from full length sections and test by the method outlined in accordance with ASTM D2412:
      a. Deflect pipe at least 35 percent without failure. Stiffness at 5 percent deflection equals or exceeds 55 pounds per square inch after the test samples have been immersed in a 5 percent solution by weight of sulfuric acid and n-Heptain for a period of 24 hours prior to testing.
      b. Failure is defined as rupture of the pipe wall.
      c. Stiffness factor may be computed by the method outlined in accordance with ASTM D2412 or by dividing the load in pounds per linear inch by the deflection in inches and 5 percent deflection.

## PART 3 EXECUTION

## 3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
   3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
   4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping, Schedule Type:
   1. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
   2. Solvent weld joints in accordance with ASTM D2855:
      a. For PVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
   3. Install piping in accordance with manufacturer's published instructions.

C. Installation of PVC piping, Class Type:
   1. Install piping in accordance with the Appendix of AWWA C900 complemented with manufacturer's published instructions.

D. Installation of PVC gravity sewer piping:
   1. The requirements for PP piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
   2. Install piping in accordance with manufacturer's published instructions, as modified and complemented in this Section.
   3. Install pipe and fittings not later than 4 months after their manufacture.

4. Provide for contraction and expansion at joints with a gasket ring.
5. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
6. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
7. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations:
    a. Provide opening for connection large enough to allow subsequent grouting around the manhole gasket.
    b. Grout around the manhole gasket and seal the opening.

E. Installation of CPVC piping:
1. Clean dirt and moisture from pipe and fittings.
2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file. Remove burrs.
3. Use solvent cement and primer formulated for CPVC:
    a. For CPVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
4. Use primer on pressure and non-pressure joints.
5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

F. Installation of PP piping:
1. The requirements for PP piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
2. Install piping in accordance with manufacturer's published instructions.

G. Installation of polyethylene (PE) tubing and fittings:
1. Install small bore PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported at close enough intervals to avoid sagging, and in continuous runs wherever possible.
2. Bundle tubing in groups of parallel tubes within protective sheath.
3. Tubes within protective sheath may be color coded, but protect tubing other than black outside the sheath by wrapping with black plastic electrician's tape.
4. Grade tubing connected to meters in one direction.

H. Installation of PE piping for underground gas distribution:
1. Socket fuse joints for piping equal or less than NPS 2.
2. Butt fuse joints for piping larger than NPS 2.
3. Install piping in accordance with requirements of the gas utility company and with manufacturer's published instructions.

I. Installation of PE piping for drain, waste, and vent:
1. Install piping as recommended in manufacturer's published instructions.

## 3.02 FIELD QUALITY CONTROL

A. Leakage test for PVC piping, Class Type:
1. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

2. Polyvinyl chloride (PVC) piping, Class Type: Subject to visible leaks test and to pressure test with maximum leakage allowance, as specified in Section 15956 - Piping Systems Testing.
3. Pressure test with maximum leakage allowance: Perform test after backfilling:
    a. Pressure: 125 pounds per square inch, gauge.
    b. Maximum leakage allowance as follows, wherein the value for leakage is in gallons per 100 joints per hour:

| NPS, Inches | 1-1/2 | 2 | 2-1/2 | 3 | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|---|---|---|---|
| Leakage | 0.41 | 0.52 | 0.63 | 0.76 | 0.98 | 1.45 | 1.88 | 2.35 | 2.80 |

B. Leakage test for HDPE piping:
1. Pressure test with maximum leakage allowance: Perform test prior to backfilling (cover pipe at intervals and/or curves if necessary to hold pipe in place during testing):
    a. Pressure: As specified in Section 15052 - Common Work Results for General Piping or 125 pounds per square inch, gauge.
    b. Test with water as test medium.
    c. Remove all free air from test section and raise pressure at steady rate to test pressure.
    d. Apply and allow initial test pressure to stand without makeup pressure for 3 hours to allow for diametric expansion or pipe stretching to stabilize.
    e. After stabilization period, return to test pressure and hold for 3 hours.
    f. Amount of makeup water allowable for expansion during pressure test in accordance with PPI Technical Report TR 31-88.
    g. No visual leaks or pressure drops allowed during final test period.

C. Mandrel tests for PVC gravity sewer and HDPE piping:
1. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
2. Perform initial mandrel test:
    a. After cleaning and completion of other tests.
    b. After placement and compaction of backfill.
    c. Before construction of pavement or surfacing.
    d. Not sooner than 30 days after pipe installation.
    e. Not later than 60 days after installation.
3. Perform final verification mandrel test:
    a. Not sooner than 30 days before the end of the warranty period.
    b. Not later than 10 days before the end of the warranty period.
    c. Consider the final verification mandrel test a warranty service, and include the costs related to final verification mandrel test in the Contract Price.

4. Utilize a 9-rod mandrel with minimum length equal to NPS and diameter as follows:

| Nominal Pipe Size (NPS) | Mandrel Diameter, inches |
|---|---|
| 6 | 5.50 |
| 8 | 7.37 |
| 10 | 9.21 |
| 12 | 10.96 |
| 15 | 13.56 |

5. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
6. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:
   a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

END OF SECTION

## SECTION 15249

## POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

### PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Schedule type PVC pipe and fittings.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   2. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   3. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   4. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   5. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   6. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
   7. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

B. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

### 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

### 1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

## PART 2 PRODUCTS

### 2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
      b. Schedule 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule.
   2. Fittings: In accordance with ASTM D2467.
      a. Same material as the pipe and of equal or greater pressure rating.
      b. Supplied by pipe manufacturer.
      c. Unions 4 inches and smaller:
         1) Use socket end screwed unions.
      d. Unions 6 inches and larger:
         1) Use socket flanges with 1/8-inch full-face soft gasket.
            a) Gasket material: As indicated on the Piping Schedule.
   3. Solvent cement:
      a. In accordance with ASTM D2564.
      b. Manufacturers: The following or equal:
         1) IPS Corp.
            a) Primer: Type P70 or another primer certified by the manufacturer for chemical service.
            b) Cement: Type 724 or another cement certified by the manufacturer for chemical service.
      c. Certified by the manufacturer for the service of the pipe.
      d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.

### 2.02 SOURCE QUALITY CONTROL

A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable.

B. Provide molded transition fittings for transitions from plastic to metal pipe.
   1. Do not thread pipe.
   2. Do not use flanged transition fittings unless specifically indicated on the Drawings.

C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

D. Provide serrated nipples for transition from pipe to rubber hose.

E. Solvent weld joints in accordance with ASTM D2855.

## 3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION

## SECTION 15278

## STEEL PIPE: EXPOSED

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Steel piping, joints, fittings, and fabricated steel piping fittings and specials.

### 1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
   3. B16.5 - Pipe Flanges and Flanged Fittings.
   4. B16.9 - Factory-Made Wrought Buttwelding Fittings.
   5. B16.12 - Cast Iron Threaded Drainage Fittings.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   2. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe: 4 inches and Larger-Shop Applied.
   3. C206 - Field Welding of Steel Water Pipe.
   4. C207 - Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 inches Through 144 inches.
   5. C208 - Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
   6. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   7. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   8. C606 - Standard for Grooved and Shouldered Joints.
   9. M11 - Steel Pipe: A Guide for Design and Installation.

D. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Casting.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
   4. A106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   5. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   6. A536 - Standard Specification for Ductile Iron Castings.
   7. C33 - Standard Specification for Concrete Aggregates.

8. C150 - Standard Specification for Portland Cement.
9. C205 - Standard Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements.
10. D297 - Standard Test Methods for Rubber Products-Chemical Analysis.
11. D395 - Standard Test Methods for Rubber Property-Compression Set.
12. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
13. D471 - Standard Test Methods for Rubber Property-Effect of Liquids.
14. D573 - Standard Test Methods for Rubber -Deterioration in an Air Oven.
15. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
16. D2240 - Standard Test Method for Rubber Property-Durometer Hardness.
17. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
18. E165 - Standard Practice for Liquid Penetrant Testing for General Industry.

E. NSF International (NSF):
1. 61 – Drinking Water System Components - Health Effects.

F. Society for Protective Coatings (SSPC):
1. SP 5 - White Metal Blast Cleaning.
2. SP 10 - Near White Wet Blast.
3. SP 11 - Bare Metal Power Tool Cleaning.
4. QP 1 - Industrial Contractor Qualification.

## 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

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 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. Details of fittings and specials showing thickness and dimensions of plates.
2. Details of welds and materials.
3. Listing of proposed services and locations for use of grooved joint type piping.
4. Tabulated layout schedules for cement-mortar lined and coated steel pipe.
5. Grooved joint piping fittings, gaskets, and couplings.
6. Grooving of pipe and fittings.

F. Calculations:
   1. Submit calculations prepared and stamped by a professional engineer licensed in the State of Utah. The calculations shall be based on the requirements defined in this Section.
   2. Design calculations: Wall thicknesses for external loading, special loading, internal pressure, and other necessary design cases.

G. Certificates of Compliance: Cement-mortar lined and coated steel pipe.

H. Mill certificates.

I. Test reports: Rubber gaskets.

## 1.04 QUALITY ASSURANCE

A. Applicable standards:
   1. Steel pipe larger than 12 inches diameter shall conform to the following standards, as complemented and modified in this Section:
      a. Steel pipe: AWWA C200.
      b. Fittings and specials: AWWA C208.
      c. Reinforcement of fittings and specials: AWWA M11.

# PART 2 PRODUCTS

## 2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Design criteria for pipe and pipe fittings: In accordance with AWWA M11 with the following modifications:
      a. Wall thickness:
         1) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
         2) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
         3) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
      b. Inside diameter of lined pipe: As measured from face to face of liner, but not less than nominal.
      c. Deflection of underground pipe inside diameter: Maximum 2 percent under trench load of H-20 live load in accordance with AASHTO specifications.
      d. Working stress of steel: Maximum 50 percent of yield stress.
      e. Contractor shall develop and submit calculations to determine the steel pipe and fitting wall thickness and design requirements according to the requirements of this specification.

## 2.02 MATERIALS

A. The requirements for steel piping materials used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Steel pipe:
   1. Type, pipe 6 inches and smaller: ASTM A53, black or galvanized, seamless or straight seam electric resistance welded. Minimum Schedule 40.
   2. Type, from 6 to 12 inches: ASTM A53, black or galvanized pipe, seamless or straight seam electric resistance welded. Minimum Schedule 20.
   3. Type, larger than 12 inches: AWWA C200, without butt strap, riveted, or swaged joints; wall thickness as specified.
   4. Type, 24 inches and larger, with grooved type couplings and wall thickness less than 1/2-inch: Provided with stub ends, sized as follows, for grooves.
      a. Thickness: As recommended by coupling manufacturer, but not less than 1/2-inch.
      b. Length: Width of coupling plus 1 inch, but not less than 6 inches.
   5. Type for liquid or gaseous dry chlorine: ASTM A106, Grade A, Schedule 80, assembled with 300 pounds per square inch malleable iron fittings and ammonia type flanges.

C. Steel pipe fittings:
   1. Screwed fittings:
      a. Malleable iron: ASME B16.3, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe.
      b. Cast iron drainage: ASME B16.12, galvanized in accordance with ASTM A153 where used with galvanized pipe.
   2. Flanged fittings:
      a. Type for 12-inch and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; or ASME B16.5, steel, 150 pounds, galvanized in accordance with ASTM A153 where used with galvanized pipe.
      b. Type for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207 and AWWA C208, fabricated from flanges and steel pipe, respectively.
      c. Companion flanges for 4 inches and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; ASME B16.5, steel, 150 pounds, slip-on or welding neck; or ammonia type for use on chlorine liquid or gas piping.
      d. Companion flanges for larger than 4 inch to and including 12-inch pipe: ASME B16.5, slip-on or welding neck type.
      e. Companion flanges for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207, steel plate or raised hub type.
      f. Weld flanges to pipe or fittings before applying lining.
      g. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
      h. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
      i. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.
   3. Welding fittings:
      a. Welding fittings for piping 8 inches and less in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, standard wall, or standard weight.
      b. Welding fittings for piping larger than 8 inches in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, or, at the option of

the Contractor, made up out of sections of pipe welded together, except where smooth bends are indicated for air lines.

c. Fittings made up of sections of pipe welded together shall be made of pipe of at least the same wall thickness as the pipe with which used, and bends shall be miter bends, fabricated in accordance with AWWA C208 and as supplemented by AWWA M11. Welding of these made-up fittings shall be in accordance with AWWA C206.
    1) Design and fabricate outlets and 4 branch fittings in accordance with AWWA M11.
    2) Bends may be welded to adjacent pipe sections.
        a) Bends shall be manufactured of the following number of pieces:
            (1) Bends from 0 to 30 degrees angle, 2 pieces.
            (2) Bends from 30 to 45 degrees angle, 3 pieces.
            (3) Bends from 45 to 67-1/2 degrees angle, 4 pieces.
            (4) Bends from 67-1/2 to 90 degrees angle, 5 pieces.

4. Grooved joint fittings:
    a. Fittings for grooved joint steel piping: Rigid-grooved type, and as follows:
        1) Grooves: Cut; rolled grooves are not acceptable.
        2) Couplings: Cast in 2 or more segments of ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
        3) Bolts and nuts: As specified in Section 15052 - Common Work Results for General Piping.
        4) Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
            a) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
            b) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion, and shall be made of nitrile in accordance with ASTM D2000, Line Call Out 2CA615A25B24.
        5) Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.
            a) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
            b) Fabricated pipe, pipe in accordance with AWWA C200, shall have shouldered ends welded onto the pipe.
            c) Shoulder: Type B or D in accordance with AWWA C606.
        6) Couplings and grooving:
            a) Manufacturers: One of the following or equal:
                (1) Gustin-Bacon Piping Products.
                (2) Victaulic Co.
    b. Fittings for grooved joint piping: Ductile iron in accordance with ASTM A536, Grade 65-45-12, or malleable iron in accordance with ASTM A47, Grade 32510, and as follows:
        1) Where cast fittings are not made, standard fittings including large diameter elbows shall be made of forged steel in accordance with ASTM A105, Grade B with 0.375 inch wall thickness, or shall be

standard segmentally welded fittings fabricated of Schedule 40 carbon steel pipe.

a) Grooves:
   (1) Manufacturers: One of the following or equal:
      (a) Gustin-Bacon Piping Products.
      (b) Victaulic Co.

2) Fittings for grooved joint piping shall be furnished by the manufacturer of the grooved joint material.
3) Fittings for grooved joint piping shall be for rigid-grooved type joints.
4) Connection to flanged units shall be by means of flange to grooved joint adapters.
   a) Where the flanged to grooved joint adapters interfere with the operation of adjacent valves, pumps, or other items, the connection shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items.

D. Steel pipe lining and coating.
   1. General:
      a. Except where otherwise specified in the Specifications or indicated on the Drawings, lining and coating for steel pipe shall be as specified in Section 15052 - Common Work Results for General Piping.

E. Fabricated steel piping fittings and specials:
   1. General: Specified in this Section are the design and fabrication of fabricated steel piping fittings and specials, which include elbows, branches, nozzles, manifolds, headers, heads, collars, stiffeners, reinforcements, and other steel fabrications relating to steel piping, but shall not include steel pipe.
   2. Design:
      a. Contractor shall design and detail fittings and specials.
         1) Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
         2) Nozzles: Reinforced in accordance with recommended practice in AWWA M11, Steel Pipe Manual.
         3) Design reinforcing for fittings and specials for the specified test pressure.
         4) Fittings shall conform in dimension to AWWA C208, complemented with the provisions specified in this Section.
         5) The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
      b. The thickness of pipe, large elbows, and headers, except header nozzles, shall be the thicker of:
         1) The thickness designed in accordance with the design methods specified in this Section.
         2) The thickness indicated on the Drawings or specified in Section 15052 - Common Work Results for General Piping Pipe Schedule, or as required by the Contractor's calculations.
         3) The following thicknesses:
            a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
            b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.

c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.

c. Elbows shall be of the number of pieces as specified in this Section, and thickness of material shall conform to thickness of pipe or manifold shells specified.
d. Ends of fittings to be welded to pipe shall be beveled for welding.

3. Fabrication:
   a. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation. Minimize number of field welds.
   b. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.
   c. Fabricate fittings and specials to allow field assembly without cutting or special work.
   d. Where specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping or indicated on the Drawings, the inside of fabricated steel manifolds and other fittings and specials shall receive a cement-mortar lining in accordance with AWWA C205.
      1) Reinforce lining for piping 24 inches in diameter and larger with wire fabric.
   e. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
      1) Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment. Properly locate and align equipment.
4. Dished heads:
   a. Dished heads on 84 inch diameter and smaller manifolds: 1 piece (seamless) spherically dished (torispherical) heads.
      1) Larger heads may be seamed.
   b. Dish radius: Same dimension as the outside diameter of the head measured at skirt.
   c. Skirt face length: Not less than 3 inches.
   d. Design heads in accordance with recommended practice in AWWA M11, Steel Pipe Manual.
5. Testing: No shop testing will be required for manifolds or piping connected thereto.

F. AWWA C200 steel pipe and fittings design and fabrication:
   1. General:
      a. Applicable standards: AWWA C200 steel pipe shall conform to the standards specified in General of this Section.
      b. Identification marks: Provide identification marks in accordance with AWWA C200. These marks shall be stenciled or otherwise shown at the top of the piping items exterior, including the following information:
         1) Name or trademark of the manufacturer.
         2) Date of manufacture of the item.
         3) Internal diameter in inches.
         4) Number of the item, sequential from initial to end station.
      c. Diameter designation: The pipe diameter specified in the Specifications and indicated on the Drawings shall be the clear inside diameter after

application of the cement-mortar lining with a tolerance of plus 0 inch and minus 1/4 inch.

2. Design:
   a. Pipe and fittings shall be designed by Contractor.
   b. Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
   c. Thicknesses of pipe, fittings and specials shall be the thicker of:
      1) The thickness designed in accordance with the design methods specified in this Section.
      2) The thickness indicated on the Drawings or specified in Section 15052 - Common Work Results for General Piping Pipe Schedule.
      3) The following thicknesses:
         a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
         b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
         c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
   d. The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
   e. Break longitudinal and girth seams for straight seam pipe shall be no greater in number than would be required for the fabrication of pipe with 96-inch by 120-inch steel plates.
      1) Break longitudinal seams at the girth seams.
   f. Calculate earth loads using the following formula:

      $$W = 120 \times H \times B$$

      wherein the various terms shall have the following meaning:

      W: Earth load, pounds per linear foot of pipe.
      H: Height of fill over the pipe, feet.
      B: Outside diameter of the pipe, feet.
      x: Mathematical symbol for multiplication.

   g. Add AASHTO's H-20 loading to earth loads.
   h. Design pipe, fittings and specials for a deflection, under external loads, not to exceed 2 percent of the diameter.
      1) Stiffness computations shall not consider the effect of the cement-mortar lining and coating.
      2) Calculate deflection using the Spangler formula and the following values:
         a) Bedding constant K = 0.100.
         b) Modulus of soil reaction E' = 700 pounds per square inch.
         c) Deflection lag constant $D_1 = 1.00$.
   i. Where piping is designated to be flanged or welded in order to restrain thrust, the design of the cylinder and flange or welded joint shall take into account the effect of stresses caused by thrust loads.

3. Materials:
   a. Coatings and linings: As required in Section 15052 - Common Work Results for General Piping.

b. Gaskets shall be as specified in Section 15052 - Common Work Results for General Piping and meet the following requirements:
    1) Minimum tensile strength, tested in accordance with ASTM D412, between 2,000 and 2,700 pounds per square inch.
    2) Minimum elongation, tested in accordance with ASTM D412, between 350 and 400 percent.
    3) Shore A durometer hardness, tested in accordance with ASTM D2240, between 50 and 65.
    4) Specific gravity, tested in accordance with ASTM D297, between 0.90 and 1.50.
    5) Maximum compression set, tested in accordance with Method B of ASTM D395, 20 percent.
    6) Maximum tension strength loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
    7) Maximum elongation loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
    8) Maximum absorption, tested in accordance with ASTM D471 at 48 hours, 70 degrees Centigrade, in air, 5 percent.

4. Joints and connections:
    a. Joints:
        1) Except as otherwise specified or indicated on the Drawings, provide lap welded or bell and spigot type joints with rubber gaskets for pipelines 54 inches and smaller.
        2) Butt-strap joints shall be used only where required for closures or where indicated on the Drawings.
        3) The joints furnished shall have the same or higher-pressure rating as the abutting pipe.
    b. Connections:
        1) Connections to existing systems shall be made using a flange isolation joint.
        2) If an existing pipeline or facility does not include a flange at or near the connection point:
            a) An isolation flange shall be placed in the first length of pipe.
            b) A butt-strap joint shall be used to connect the first length of pipe to the existing pipeline.
    c. Bell and spigot joint rings: Rolled Carnegie shape M-3516.
    d. Lap welded joints:
        1) Double fillet weld lap welded joints shall be welded on the inside and outside of the joint.
        2) Lap joints prepared for electric field welding shall be in accordance with AWWA C206.
        3) Joint forming:
            a) Joint geometry and joint field weld will be such that no part of any field weld will be closer than 1 inch to the nearest point of tangency to the bell radius.
            b) Bell ends shall be formed by and expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.

4) Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.

e. Butt-strap joints: Butt-strap joints where used or required, shall be:
   1) A minimum of 10 inches wide.
   2) The same thickness as the pipe wall.
   3) Provide for a minimum of 2-inch lap at each pipe joint.
   4) Double fillet weld each side of joint on the inside and outside of the joint.

f. Flanges: AWWA C207, Class D, steel ring, and as follows:
   1) Match pipe flanges to the valve flanges:
      a) At flanged joints connecting to valves, provide a steel pipe section without rod reinforcing and not less than 24 inches in length.
      b) Apply cement-mortar lining and coating to the steel pipe section.
   2) Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
   3) Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

5. Fabrication:
   a. Shop coat of primer: Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
   b. Bend radii of fittings: Not less than 2.0 times the nominal diameter in accordance with AWWA C208.

## 2.03 COATING AND LINING - GENERAL

A. Coating and lining shall be as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping.

B. Extend pipe coatings for underground piping 6-inches above finished grade or 3-inches above finished floor, and neatly terminate.

C. As specified in Section 01600 - Product Requirements.

D. Prepare, install, and repair in accordance with manufacturer's requirements.

E. Contractor is responsible for:
   1. That coating selected is suitable for the application conditions anticipated, such as temperature, humidity, etc.
   2. Managing the project schedule to allow adequate cure time before backfill or immersion based on surface temperatures at the time of application.

## 2.04 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C205 and as specified in this Section).
   1. Cement:
      a. Cement: In accordance with ASTM C150, Type II.
   2. Water:
      a. In accordance with AWWA C205 and as specified in this Section.
   3. Sand and aggregate:
      a. In accordance with AWWA C205.

b. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

B. Lining:
1. 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.
2. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
3. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C205 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 gage spaced at maximum 1-inch centers.
2) No. 14 gage steel wire at maximum 1/2-inch centers.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. The requirements for installation of steel pipe used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Joints:
1. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
2. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
3. Unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping, pipe joints shall be as follows:
a. Pipe smaller than 2 inches in nominal diameter shall have screwed joints or flexible couplings.
b. Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
c. Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.

C. Screwed joints:
1. Perform threading with clean, sharp dies.
a. Wavy, rough, or otherwise defective pipe threads are not acceptable.
2. Make screwed joints tight and clean with an application of Teflon™ tape or approved paste compound applied to the male threads only, except as follows:
a. Make up liquid and dry chlorine lines, and liquefied petroleum gas lines, with litharge and glycerin.

3. Provide railroad type unions with bronze-to-iron seat, galvanized where used with galvanized pipe.
    a. Flanged joints may be used instead of unions.

D. Flanged joints:
1. In flanged joints, flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
2. Attach slip-on flanges to pipe by 2 fillet welds, in accordance with AWWA C207.
3. Secure welding neck flanges with full penetration butt welds without backing rings.
    a. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.

E. Welded joints:
1. Welded joints shall be electric welded in accordance with AWWA C206.
2. Welders shall be qualified pursuant to the provisions of AWWA C206.
    a. Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
3. Do not weld galvanized pipe.

F. Grooved joints:
1. Piping with grooved joints shall be installed where indicated on the Drawings and may be installed in place of flanged piping and screwed piping, except that grooved joint piping shall not be used in the following installations:
    a. In underground and underwater installations.
    b. In piping subject to test pressures of 150 pounds per square inch gauge, or more.
    c. In steam and gas piping.
    d. In sludge and scum piping designed to be steam cleaned.
2. Assemble in accordance with manufacturer's published instructions.
3. Support grooved-end pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.

## 3.02 DEFECTS IN COATINGS EXCEPT CEMENT MORTAR

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
1. Pipe joints exceeding the following defect maximum will be rejected.
    a. Minor defects:
        1) No more than 1.5 per 100 square feet of surface area.
        2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
        3) Repairs for adhesion testing will not be included in the total number of repairs.
        4) Repair in accordance with manufacturer's requirements.
    b. Major defects:
        1) No more than 3 major repairs on each pipe joint.
        2) No more than 30 percent repairs on the pipe surface area with defects.

2. Minor repairs:
    a. Repairs less than 8 inches in the greatest dimension.
    b. Repair in accordance with manufacturer's requirements.
3. Major repairs:
    a. Repairs that exceed 8 inches in the greatest dimension.
    b. Repair in accordance with manufacturer's requirements.

## 3.03 CEMENT MORTAR

A. Lining:
    1. Field applied interior joint lining:
        a. Field applied lining shall be of the same density, smoothness, and thickness as shop applied lining.
        b. After the backfill has been completed to final grade, fill interior joint recess with tightly packed cement mortar.
            1) Trowel flush with the interior surface with no indentation or projection of the mortar exceeding 1/16-inch.
            2) Remove excess cement mortar.

## 3.04 PLURAL COMPONENT EPOXY

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining.
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

## 3.05 PLURAL COMPONENT POLYURETHANE

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining.
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

## 3.06 FIELD QUALITY CONTROL

A. Field test fabricated steel manifolds with the pipe to which they connect.

B. Weld testing:
    1. Liquid penetrant testing:
        a. As soon as possible after welding of pipeline joints, all fillet welds shall be tested by the liquid penetrant inspection procedure in accordance with ASTM E165 under Method “B” and “Leak Testing”.
        b. Chip out defects, rebell, and retest.
            1) Upon retest, the repaired area shall show no leaks or other defects.

END OF SECTION

## SECTION 15286

## STAINLESS STEEL PIPE AND TUBING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Stainless steel piping and tubing.

### 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.
   3. B16.11 - Forged Fittings, Socket-Welding and Threaded.
   4. B31.3 - Process Piping.
   5. B36.19 - Stainless Steel Pipe.

B. ASTM International (ASTM):
   1. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   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 and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   8. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   9. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   10. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
   11. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   12. A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.

13. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
14. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
15. A789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
16. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
17. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
18. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
19. B622 - Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube.
20. B912 - Standard Specification for Passivation of Stainless Steels Using Electropolishing.
21. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

C. American Welding Society (AWS):
1. D1.6 - Structural Welding Code - Stainless Steel.

## 1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop Drawings:
1. Detailed layout drawings:
   a. Dimensions and alignment of pipes.
   b. Location of valves, fittings, and appurtenances.
   c. Location of field joints.
   d. Location of pipe hangars and supports.
   e. Connections to equipment and structures.
   f. Location and details of shop welds.
2. Thickness and dimensions of fittings and gaskets.
3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
4. Material specifications for pipe, gaskets, fittings, and couplings.
5. Data on joint types and components used in the system.

## PART 2 PRODUCTS

### 2.01 DESIGN AND PERFORMANCE CRITERIA

A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
   1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
   2. Where joints and couplings are specifically indicated on the Drawings, design and shop-fabricate piping sections utilizing the joint or coupling illustrated at the locations shown.
   3. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly:
   1. Field welding is prohibited.
   2. Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings.

### 2.02 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall thickness:
   1. As specified in Section 15052 - Common Work Results for General Piping.

C. Piping material and manufacturing:
   1. Comply with the requirements outlined in the following table:

| Service | Stainless Steel Grade | Pipe Manufacturing Process |
|---|---|---|
| For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures. | | |
| Piping 3 inches in nominal diameter and larger | Type 304L stainless steel in accordance with ASTM A240 | In accordance with ASTM A778 |
| Piping less than 3 inches in nominal diameter | Type 304L stainless steel in accordance with ASTM A240 | In accordance with ASTM A312 |
| Digester Gas, Oxygen and Ozone Service, Membrane and Reverse Osmosis Filtration Systems with chloride concentrations less than 1,000 parts per million and/or free chlorine less than 4 parts per million at ambient temperatures. | | |
| Piping 3 inches in nominal diameter and larger | | Type 316L in accordance with ASTM A778 |

| Service | Stainless Steel Grade | Pipe Manufacturing Process |
|---|---|---|
| | Type 316L or LDX 2101 stainless steel in accordance with ASTM A240 | Type LDX 2101 in accordance with ASTM A790 |
| Piping less than 3 inches in nominal diameter | Type 316L or LDX 2101 stainless steel in accordance with ASTM A240 | Type 316L in accordance with ASTM A312 |
| | | Type LDX 2101 in accordance with ASTM A790 |
| Brackish water Membrane and Reverse Osmosis Membrane Filtration Systems with chloride concentrations between 1,000 and 10,000 parts per million. | | |
| All piping diameters | Austenitic or duplex grades of material with PREN greater than 33 | In accordance with ASTM A312, ASTM A778, ASTM A790, or ASTM A928 |
| Brackish and Seawater Membrane and Reverse Osmosis Membrane Filtration Systems with chloride concentrations between 10,000 to 20,000 parts per million | | |
| All piping diameters | Austenitic and duplex grades of material with PREN greater than 40 | In accordance with ASTM A312, ASTM A790 or ASTM A928 |
| Brackish and Seawater Reverse Osmosis Concentrate (i.e., Brine) with chloride concentrations greater than 20,000 parts per million | | |
| All piping diameters | Austenitic and duplex grades of material with PREN greater than 45 | In accordance with ASTM A312, ASTM A778, ASTM A790, or ASTM A928 |
| PREN: Pitting Resistance Equivalency Number<br>PREN = Cr% + (3.3 x Mo%) + (16 x N%) | | |

| UNS # | Alloy | Cr% | Mo% | N% | Other | PREN |
|---|---|---|---|---|---|---|
| N10276 | C-276 | 14.5-16 | 15-17 | - | W 3-4.5 | 64 |
| S32750 | Alloy 2507 | 24-26 | 6-8 | 0.24-0.32 | - | 48 |
| S32654 | 654SMO | 24-25 | 7-8 | - | - | 47 |
| N06625 | Alloy 625 | 20-23 | 8-10 | - | Cb 3.25-4.15 | 46 |
| N08366 | AL6XN | 20-22 | 6-7 | - | - | 40 |
| | | | | | | |
| N06985 | Alloy G | 21-23.5 | 5.5-7.5 | - | - | 39 |
| S32760 | Zeron 100 | 24-26 | 3-4 | 0.2-0.3 | W 0.5-1.0 | 37 |
| S32205 | Alloy 2205 | 22-23 | 3-3.5 | 0.14-0.20 | - | 34 |
| N08904 | 904L | 19-23 | 4-5 | - | - | 32 |
| S31726 | 317LNM | 17-20 | 4-5 | 0.1-0.2 | - | 32 |
| | | | | | | |
| N08825 | Alloy 825 | 19-23.5 | 2.5-3.5 | - | - | 27 |

| UNS # | Alloy | Cr% | Mo% | N% | Other | PREN |
|---|---|---|---|---|---|---|
| S32101 | LDX-2101 | 21.5 | 0.3 | 0.22 | - | 26 |
| S31603 | 316L | 16-18 | 2-3 | - | - | 23 |
| S30403 | 304L | 18-20 | - | - | - | 18 |

D. Fittings for piping 3 inches in nominal diameter and greater:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A774.
   3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Dimensional standards:
      a. Fittings with weld ends: In accordance with ASME B16.11.
      b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Fittings for piping less than 3 inches in diameter:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A403, Class WP.
   3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Forgings in accordance with ASTM A182, or barstock in accordance with ASTM A276. Match forging or barstock material to the piping materials.

F. Piping joints:
   1. Joint types, piping greater than 2 inches in diameter, general:
      a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
      b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping, Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:
         1) Welded joints.
         2) Flanged joints.
         3) Grooved joints.
      c. Joints at valves and pipe appurtenances:
         1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
         2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using flanged coupling adapters or flanged joints.
            a) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system and in accordance with requirements as specified in Section 15121 - Pipe Couplings.

d. Joints in oxygen piping systems:
    1) Aboveground piping: Welded, flanged, or grooved.
    2) Underwater piping: Welded or flanged.
    3) Buried piping: Welded or mechanically restrained.
2. Joints in piping 2 inches in diameter and smaller: Flanged, grooved, welded, or screwed with Teflon™ tape thread lubricant.
3. Welded joints:
    a. Piping 12 inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures.
    b. Piping 4 inches through 12 inches in diameter: Double butt welded joints.
    c. Piping less than 4 inches in diameter: Single butt-welded joints.
    d. Mark each weld with a symbol that identifies the welder.

G. Gaskets:
1. Ozone and oxygen service: TFE sheet.
2. Aeration air service: As specified in Section 15052 - Common Work Results for General Piping.
3. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.

H. Bolts for flanges:
1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A193 heavy hex head.
    a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
    b. Nuts: In accordance with ASTM A194 heavy hex pattern.

I. Fabrication of pipe sections:
1. Welding: Weld in accordance with ASME B31.3.
2. Weld seams:
    a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.
    b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
    c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
    d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and passivation:
1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
2. Clean (pickle) and passivate in accordance with ASTM A380 or ASTM A967.
    a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
        1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
    b. Passivation treatments with citric acid are not allowed.
3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

K. Electropolishing:
   1. Required for the following stainless steel piping:
      a. Pipe interior: All piping.
      b. Pipe exterior: All piping except concrete encased piping.
   2. For piping greater than 2 inches in diameter:
      a. Electropolish stainless steel pipe inside and out in accordance with ASTM B912.
         1) Electropolish process: Remove no more than 5 micrometers from the surface.
      b. Following shop fabrication of pipe sections, straight spools, fittings, and other components, prepare surface using preparatory and cleaning procedures in accordance with ASTM A380.
         1) Wipe items with appropriate solvent to remove any marks, sugar, markers, or crayon.
      c. A post dip in room temperature 10 to 30 percent nitric acid solution is required to remove residuals from the electropolishing process and to provide a shine to the metal surface.
         1) Follow the post dip procedure by final rinsing with water to remove residual acid or any other materials that may affect the appearance or performance of the passivated part.
      d. Finished surfaces: Free of imperfections such as pitting, etches, burn marks or stains.
   3. For piping less than 2 inches in diameter:
      a. Following shop fabrication of piping sections, descale, clean and seal piping section in accordance with CGA Standard G-4.1.

## 2.03 STAINLESS STEEL TUBING

A. Stainless steel tubing:
   1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A269, wall thickness not less than 0.035 inch.

B. Fittings: Swage ferrule design:
   1. Components made of:
      a. Type 316 stainless steel.
   2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
   3. Flare type fittings are not acceptable.
   4. Manufacturers: One of the following, or equal:
      a. Crawford Fitting Co., Swagelok.
      b. Hoke, Gyrolok.
      c. Parker, CPI.

C. Valves for use with stainless steel tubing:
   1. Ball type valves with swage ends to match tubing diameter.
   2. Constructed from:
      a. Type 316 stainless steel with TFE seats.
   3. Manufacturers: The following or equal:
      a. Crawford Fitting Co., Swagelok.

## 2.04 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A774.
   1. Supplementary testing is not required.

D. Examine 3 percent or up to 20 of the factory welds by radiography. For each weld that fails, inspect 3 additional welds using the same methods:
   1. Radiographic methods: In accordance with standards of AWS Standard D1.6 (Chapter 6). and
   2. For each weld found to be defective by radiographic methods, examine 3 additional welds using the same method.
   3. Provide interpretation of radiographic pictures by an independent testing laboratory acceptable to the Engineer and submit written report of the findings issued by the laboratory.
   4. Repair or replace defective joints.

E. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

F. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

G. Shipment to site:
   1. Protect flanges and pipe ends by encapsulating in dense foam.
   2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
   3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
   4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
   5. Notify Engineer when deliveries arrive so Engineer may inspect the shipping conditions.
   6. Engineer may reject material due to improper shipping methods or damage during shipment.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install piping in such a manner as not to impart strain to connected equipment.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

### 3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

### 3.03 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as specified in Section 15052 - Common Work Results for General Piping.
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

### 3.04 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

## SECTION 15400

## PLUMBING SYSTEMS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Requirements for materials and installation of plumbing systems.

### 1.02 REFERENCES

A. American Concrete Institute (ACI).

B. American Gas Association (AGA).

C. American National Standards Institute (ANSI):
   1. Z21.15 - Manually operated gas valves for appliances, appliance connector valves and hose end valves.

D. American Society of Mechanical Engineers (ASME).
   1. B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.
   2. B16.12 - Cast Iron Threaded Drainage Fittings.

E. American Society of Sanitary Engineering (ASSE):
   1. 1070 - Performance Requirements for Water Temperature Limiting Devices

F. American Water Works Association (AWWA):
   1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
   2. C700 - Standard for Cold-Water Meters -- Displacement Type, Bronze Main Case.
   3. C702 - Standard for Cold-Water Meters -- Compound Type.
   4. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).

G. Americans with Disabilities Act (ADA).

H. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
   4. A518 - Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
   5. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   6. A861 - Standard Specification for High-Silicon Iron Pipe and Fittings.

7. A888 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
8. B32 - Standard Specification for Solder Metal.
9. B88 - Standard Specification for Seamless Copper Water Tube.
10. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
11. B823 - Standard Specification for Materials for Copper Base Powder Metallurgy (PM) Structural Parts.
12. C552 - Standard Specification for Cellular Glass Thermal Insulation.
13. C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
14. D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
15. D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride (CPVC) Compounds.
16. D1785 - Standard Specification for Poly(Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
17. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
18. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
19. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
20. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
21. D2843 - Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics.
22. D2863 - Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index).
23. D4101 - Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials.
24. F1412 - Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems.

I. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. IS 03 - Copper plumbing Tube Pipe and Fittings.

J. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

K. Outside diameter (O.D.)

L. Plumbing and Drainage Institute (PDI):
   1. WH 201 - Water Hammer Arresters Standard.

M. Underwriters Laboratories, Inc. (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

N. United States Environment Protection Agency (EPA): Water Sense.

## 1.03 REQUIREMENTS

A. Include in plumbing system:
   1. Fixtures.
   2. Drain, vent, and water piping.
   3. Connections and cleanouts.
   4. Fittings and accessories.
   5. Parts and pieces necessary to provide a complete system.
   6. Testing for complete and functional system.

B. Except in typical details, piping is indicated on the Drawings in diagrammatic form. Sizes and locations are indicated on the Drawings; however, not every offset and fitting, nor every structural difficulty that will be encountered in the Work has been indicated.

C. Modify piping alignment indicated on the Drawings as necessary to avoid structural or mechanical obstructions and to clear the work of other trades.

## 1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination.
   1. Roof:
      a. Provide plumbing equipment roof penetrations information required in the preparation of roofing drawings including, but not limited to:
         1) Location.
         2) Diameter.
         3) Configuration of penetration and the surround.
      b. Provide roof mounted plumbing equipment information required in the preparation of roofing drawings including, but not limited to:
         1) Location.
         2) Size.
         3) Weight.
         4) Anchoring and support details.

## 1.05 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings, as applicable:
   1. System layout, mechanical, electrical power, and control diagrams.
   2. Nameplate information.
   3. Materials.
   4. Coatings and linings.
   5. Rough-in drawings.
   6. Supports, vibration isolators, and seismic bracing calculations and details.
   7. Primary and ancillary equipment.
   8. Proposed cutting and patching.
   9. Maximum recommended equipment vibration levels and field-testing method.
   10. Copy of factory test results.

C. Product data: As specified in Section 15110 - Common Work Results for Valves.

D. Commissioning submittals:
   1. Backflow preventer certification.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

E. Operation and maintenance data as specified in Section 01782 - Operation and Maintenance Manuals.

F. Field testing documentation.

G. Warranties.

H. Detailed piping alignment drawings.

## 1.06 QUALITY ASSURANCE

A. Work to be in accordance with the plumbing code specified in Section 01410 - Regulatory Requirements, and in accordance with applicable laws and regulations, including requirements for accessibility, energy, water conservation, and health related requirements for water fountains and coolers.
   1. Where provisions specified in these Specifications or indicated on the Drawings are in conflict with the plumbing code specified in Section 01410 - Regulatory Requirements or laws or regulations, the Code and the laws or regulations take precedence over the specified provisions and design.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

## 2.02 FIXTURES

A. General:
   1. Fixture fittings and piping which are exposed shall be heavy-duty chrome.
   2. Stops:
      a. Fixtures, except showers, shall have stops at the fixtures' service.
      b. Stops for laboratory equipment, and for other equipment or fixtures for which stops have not been otherwise specified in this Section, shall be chrome-plated straight pattern compression stops or chrome-plated angle pattern compression stops.
   3. Escutcheons to be used for all wall penetrations:
      a. Material: Chrome-plated steel plate.
      b. Manufacturers: One of the following or equal:
         1) Dearborn Brass Co., Model Number 5358.
         2) Keeney Manufacturing Co., Model Number 102 or Number 105.

B. Service sinks:
   1. General:
      a. Service sinks do not require ADA compliance.

b. Sink manufacturer to supply faucet, mounting hardware, and installation fittings.
c. Faucet:
1) Exposed yoke, wall-mounted, top braced.
2) Rigid spout with 3/4-inch threaded hose end and bucket hook.
3) Deliver not more than 10 gpm at 60 psig inlet.
4) Manual lever.
d. Center drains with strainer.
e. Provide 5-foot hose with wall hook and rigid end spout at each service sink.

2. MS, Floor-sitting, corner service mop sink:
a. Bowl:
1) Cast iron, enameled.
2) Nominal: 28 inch by 28 inch by 13 inch deep.
3) Removable vinyl coated rim guard.
b. Exposed yoke wall-mounted utility faucet.
c. Manufacturers: One of the following or equal:
1) American Standard, Florwell.
2) Kohler.

3. SK, Floor-mounted service sink:
a. General:
1) ADA compliance not required.
b. Floor mounted, Type 304 stainless steel, 16 gauge.
1) Tubular stainless-steel legs with adjustable bullet feet.
a. Two Bowl:
1) Bowl: 18 by 24 by 14 inches deep.
2) Coved corners.
b. Backsplash: 9 inch (minimum) with tile ledge.
c. Faucet:
1) 8-inch arc tube spout.
2) 10 gpm maximum flow rate at 60 psig inlet.
3) Manual lever.
a. Manufacturers: One of the following or equal:
1) Elkay, Dependabilt 2C24X24-0X.
2) Advance Tabco.
3) American Standard.

C. KS, Kitchen sinks:
1. General:
a. Self-rimming, Type 304 stainless steel, 18-gauge.
b. Nominally 33 inches by 22 inches by 6 inches deep.
c. Sound dampened.
d. Undercoated.
e. Offset drain.
f. Stainless steel waste fitting.
g. Faucet.
1) High arch, pull-down.
2) 2.2 gpm maximum flow rate.
3) Manual lever.
h. Manufacturers: One of the following or equal:
1) American Standard, Edgewater.

2) Kohler.
i. Double bowls, equal size.
1) Zero radius corners.
2. Garbage Disposal: 40-ounce stainless steel grind chamber and components; 1 horsepower, 120 Volt single phase with wall switch for on/off control; auto-reversing capability; permanently lubricated upper and lower bearings; 1-1/2-inch drain connection; provide vibration inhibiting mounting accessories for installation on sink drain.
3. Manufacturers: One of the following or equal:
a. American Standard, Inc.
b. Crane Co.
c. Eljer Ind.
d. Kohler Co.

D. Toilets, urinals, lavatories, and showers:
1. Provide as indicated on the Drawings.
2. Meet ADA accessibility standards.
3. EPA WaterSense labeled.
4. WC, Flush valve water closets:
a. Wall mounted vitreous china elongated bowl.
b. Water-saver type, siphon jet action; 1-1/2-inch top spud; chrome-plated flush valve with vacuum breaker; non-hold-open type handle with flush volume adjustability at 1.28 gallons per flush; 1-inch screwdriver angle stop and flush connection.
c. White solid plastic seat with open front, stainless steel hinge and check.
d. Concealed carrier:
1) Mounting height as required.
e. Flush valve:
1) Automatic:
a) Battery powered.
b) Self-cleaning piston.
c) ADA compliant universal sensor.
f. Manufacturers: One of the following or equal:
1) Flush valve water closets:
a) American Standard, Inc.
b) Crane Co.
c) Kohler Co.
5. UR, Flush type urinals:
a. Wall-mounted with concealed hanger vitreous china washout bowl.
b. 3/4-inch top spud, outlet connection threaded 2 inches inside; flush chrome-plated brass valve with vacuum breaker; 0.5 gallons per flush; 3/4-inch screwdriver stop and flush connection; and concealed carrier.
c. Flush valve:
1) Automatic:
2) Battery powered.
3) Self-cleaning piston.
4) ADA compliant universal sensor.
d. Manufacturers: One of the following or equal:
1) Urinals:
a) American Standard, Inc.
b) Crane Co.

c) Kohler Co.

6. LAV, Lavatories:
   a. Wall mounted 20-inch by 18-inch vitreous china bowl with backsplash and front overflow.
   b. Concealed arms and concealed wall hanger.
   c. 1-inch diameter drilling for soap dispenser and soap depression.
   d. Faucet:
      1) Automatic flow control
      2) Battery operated, on time adjustable
      3) Flow rate: 0.5 gpm maximum at 60 psig inlet
   e. Manufacturers: One of the following or equal:
      1) Lavatory:
         a) American Standard, Inc.
         b) Crane Co.
         c) Eljer Ind.
         d) Kohler Co.
7. SH, Shower fixtures:
   a. General
      1) Shower faucet:
         a) Require DOE compliance.
         b) Temperature regulation and anti-scald protection.
         c) Single handle.
         d) Manual lever.
   b. Shower Head: Hand shower:
      1) ADA approved.
      2) Provide shower fixtures complete with adjustable spray handshower, holder, adjustable escutcheon flange, volume and temperature control valve, hot limit safety stop, single metal lever handle, chrome finish, 1/2-inch female IPS union supplies and 1.75 gallons per minute flow restrictor at 45 psig inlet pressure. Provide 30-inch slide bar accessory for adjustment of holder height.
   c. Manufacturers: One of the following or equal:
      1) Kohler, Purist K-22178-G-CP.
      2) American Standard.

## 2.03 PLUMBING AND DRAINAGE PRODUCTS

A. Backflow preventers:
   1. Design: Reduced pressure chamber type in accordance with AWWA C511.
   2. Include shutoff valves at each end of backflow preventer with properly located test cocks.
   3. Shutoff valves:
      a. Backflow preventers 2-inch and smaller: Provide with full-port, quarter turn, resilient seated ball valves.
      b. Backflow preventers larger than 2-inch: Provide with resilient seated, outside stem and yoke gate valves.
   4. Manufacturers: One of the following or equal:
      a. Febco backflow prevention:
         1) Model LF860 all sizes.

b. Zurn/Wilkins:
    1) Model 975LX2 for 1/2-inch through 2-inch.
    2) Model 375AST for sizes 2 1/2 inch, 3 inch, 8 inch, and 10 inch.
    3) Model 375 and 375DA for sizes 4 inch and 6 inch.
c. Watts regulator: Series LF909.
    1) Josam Co. 75000.
    2) Zurn Ind., Inc., Series Z-1700.

B. Water hammer arresters:
1. Stainless steel shell.
2. Hydro-pneumatic cushion of argon gas.
3. Elastomer bellows, stainless steel adapter, and female threaded plug.
4. Size arresters for each fixture supply branch:
    a. Determined in accordance with the PDI Standard PD1-WH201.
5. Manufacturers: One of the following or equal:
    a. Jay R. Smith Manufacturing Co., Series 5000.
    b. Josam Co. 75000.
    c. Zurn Ind., Inc., Series Z-1700.

C. Trap primers:
1. Mechanical type:
    a. Automatic trap primer valve with distribution unit and air gap.
    b. Trap primer leader lines shall be 1/2-inch type L copper piping.
    c. Manufacturer: One of the following or equal:
        1) Precision Plumbing Products (PPP) Prime Rite.
        2) J.R. Smith Model 2699.
2. Trap seals:
    a. Provide trap seal on floor drains where mechanical trap primer leader lines cannot serve floor drains.
    b. Manufacturer: The following or equal:
        1) ProVent Systems Trap Guard.
        2) Jay R Smith "Quad Close" Trap Seal Device.
        3) IPS Green Drain Waterless Trap Seal.

D. Cleanouts:
1. Wall-mounted cleanouts for concealed piping:
    a. Cast-iron tapped tee.
    b. Round smooth stainless steel access cover and securing screw.
        1) Manufacturers: One of the following or equal:
            a) Josam Co., 58910-19 (Tee & Plug) and 58600 (Access Cover).
            b) Zurn Ind., Z1445-BP.
2. Floor cleanouts:
    a. Cast-iron ferrule, countersunk plug, gastight and watertight seal.
    b. Adjustable cleanout head extension.
    c. Scoriated nickel-bronze top and securing screw.
        1) Heavy-duty top suitable for heavy traffic conditions in unfinished floor areas.
    d. Manufacturers: One of the following or equal:
        1) Josam Co., 56670 for finished floors, 55000 for unfinished floors.
        2) Zurn Ind., Inc., ZN-1400 for finished floors, ZN-1400-HD for unfinished floors.

3. Yard cleanouts in asphalt or ground areas:
    a. As specified for floor cleanouts in unfinished floor areas.

E. Equipment and floor drains:
1. Adjustable strainer head, floor level grate.
2. 4-inch diameter funnel extension.
3. No-hub outlet and nickel bronze top.
4. Manufacturers: One of the following or equal:
    a. Floor drain:
        1) Josam Co., 30000-A, combination drip drain, less clamping collar.
        2) Zurn Ind., Inc., ZN-415 strainer.
    b. Funnel extension:
        1) Josam Co., E-2.
        2) Zurn Ind., Inc., ZN-328.

F. Other floor drains:
1. No-hub outlet.
2. Nickel bronze Type B strainer:
    a. Josam Co., 30000-A universal floor drain with adjustable strainer, less clamping collar.
    b. Zurn Ind., Inc., ZN-415.
    c. Strainer sizing:
        1) 3-inch drain strainers: 6-inch diameter.
        2) 4-inch drain strainers: 8-inch diameter.

G. Floor sinks for slabs above grade:
1. Full, half, or quarter grate, 12 inches square by 6 inches deep, acid resisting enamel interior and exterior, no hub outlet, pipe size as indicated on the Drawings.
2. Manufacturers: One of the following or equal:
    a. Josam Co., 49320A.
    b. Zurn Ind., Inc., Z 1900.

H. Floor sinks for slab on grade:
1. Full, half, or quarter grate.
2. 16 inches square by 12 inches deep.
3. Acid resisting enamel interior and exterior, no hub outlet.
4. Pipe size as indicated on the Drawings.
5. Manufacturers: One of the following or equal:
    a. Josam Co., 49420.
    b. Zurn Ind., Inc., Z 1926.

I. Hose bib stations:
1. A 3/4 or 1-inch hose bib shall be a single supply wall mounted hose bib station complete as described below and as indicated on the Drawings.
2. Refer to detail for requirements for hose rack.
3. The hose shall be 50 feet of 3/4 or 1-inch commercial/industrial grade rubber hose.
4. The hose nozzle shall be a 7-pattern select-a-spray with vinyl grip. Unit shall include a hold-open clip for continuous spraying, a rust resistant stainless steel spring, and a lifetime leak proof seal.

5. Manufacturers: The follow or equal:
    a. Flexon Pro Series.
    b. Gilmore Group.

J. Three-Way Mixing Valve:
1. Materials:
    a. Forged brass body, less than or equal to .25 percent lead brass.
    b. Noryl GFN2 internal components.
    c. Viton seals.
    d. Polysulfone piston.
    e. Fittings: Provide model to match fitting type for pipe system:
        1) CPVC.
        2) Sweat.
        3) NPT.
    f. EPDM gaskets.
    g. Stainless-steel temperature gauge.
2. Performance
    a. Max flow rate: 20 gallons per minute.
    b. Min flow rate: 1 gallon per minute.
    c. Hot supply temperature: 120 to 180 degrees Fahrenheit.
    d. Cold supply temperature: 39 to 80 degrees Fahrenheit.
    e. Max inlet pressure: 230 pounds per square inch.
    f. Max variation in supply pressure: 20 percent.
    g. Min temperature differential between hot supply and mixed: 10 degrees Fahrenheit.
    h. Outlet temperature range: 85 to 175 degrees Fahrenheit.
    i. Factory set to 115 to 120 degrees Fahrenheit.
    j. Accuracy of outlet temperature: ± 3 degrees Fahrenheit.
3. Manufactures: The follow or equal:
    a. Taco Comfort Solutions, 5000 Series Lead-Free Mixing Valve.

## 2.04 EQUIPMENT

A. General:
1. As specified when applicable in Section 15050 - Common Work Results for Mechanical Equipment.

B. Electric water cooler with bottle filling station:
1. Wall mounted electric water coolers:
    a. Provide complete cabinet with stainless steel fountain top; bonderized steel cabinet with finish colors selected by the Owner from manufacturer standard colors; bubbler and guard; cold water flow control with pushbutton; air cooled refrigeration system with 1/5 horsepower compressor for 115 volts, 1 phase, 60 hertz electric power supply; 1/2-inch water supply connection with union connected service stop; 1-1/4 inch waste connection with "P" trap; and a capacity to cool 8 gallons per hour from 80 degrees Fahrenheit to 50 degrees Fahrenheit at ambient temperatures of 90 degrees Fahrenheit.
    b. Do not allow potable water flow through drinking fountain and its connections to come in contact with lead or a lead alloy.

c. Bottle fill station:
    1) Provided with no-touch sensor activation with automatic 20 second shut off timer.
    2) Fill rate: 1.1 to 1.5 gpm.
    3) LED filter monitor to indicate when filter needs replacement.
    4) Provide high-left installation on cooler.
    5) Rated for indoor use.
    6) Provide bubbler.
d. Manufacturers: One of the following or equal:
    1) Elkay Manufacturing Co.
    2) Halsey Taylor.
    3) Sunroc Corp.

C. Water heaters:
1. Size and requirements as indicated on the Drawings.
2. Provide with temperature limiting device meeting ASSE 1070.
3. Provide expansion tank with all tanked water heaters that are sized per manufacturer requirements.
4. Gas tanked water heaters:

a. Glass lined, heavy gauge steel tank:
    1) Pressure tested to 150 psig.
    2) Finished with factory standard baked enamel.
b. 2 inches minimum fiberglass insulation.
c. Automatic, 100 percent gas pressure regulated thermostat:
    1) Adjustable to deliver 180 degrees Fahrenheit water.
d. Provide unit complete with ASME rated temperature and pressure relief valve.
e. Magnesium anode.
f. Tank cleanout.
g. Provide and install vent piping per manufacturer. Flue shall be constructed of CPVC Schedule 40.
h. Certified and listed by the AGA.
i. Manufacturers: One of the following or equal:
    1) A. O. Smith Corp.
    2) Rheem Water Heater.
    3) State Ind., Inc.
j. Warranty:
    1) Special warranty:
        a) Duration: Provide 3-year warranty.
k. Recirculation pump:
    1) Construction: Cast iron casing, flanged, non-metallic impeller.
    2) Lead-free and suitable for use in domestic water and closed loop heating applications.
    3) UL listed and compliant with the Safe Drinking Water Act.
    4) Flow: 15 GPM.
    5) Total Head: 3 feet.
    6) Electrical:
        a) Volts/Ph: 115V/1Ph.
        b) Amps: 0.74A.
        c) Horsepower: 1/25HP.

7) Manufacturer: One of the following or equal:
a) Taco Comfort Solutions, Model 007-F5.

D. Water meters:
1. Displacement-type water meters:
a. Description:
1) Standard: AWWA C700.
2) Pressure rating: 150 psig working pressure.
3) Body design: Nutating disc; totalization meter.
4) Registration: In gallons or cubic feet as required by utility company.
5) Case: Bronze.
6) End connections: Threaded.
b. Manufacturers: One of the following or equal:
1) Neptune, T-10 Series.
2) Mueller Co.; Water Products Division, similar series.
3) Sensus Metering Systems, similar series.

E. Pressure Regulator:
1. Metallic pressure reducing valves for water service, 2 1/2 inches and smaller:
a. Manufacturers: One of the following or equal:
1) Watts, Series LF223.
2) Zurn Wilkins, 500 Series.
b. Direct operated, single seat type pressure reducing valve.
c. Downstream pressure adjustment range: 30 to 300 pounds per square inch gauge (psig).
d. Materials:
1) Body and spring cover: Bronze or brass alloy meeting the zinc and aluminum requirements of Section 40_05_51.01 - Common Work Results for Valves.
2) Valve seat: Type 316 stainless steel.
3) Diaphragm: Reinforced Buna Nitrile.
4) Disc: EPDM.
2. Metallic pressure reducing valves for water service, 3 inches and larger:
a. Manufacturers: One of the following, or equal:
1) Watts, Ames Fire & Waterworks ACV Series LF910GD.
2) Cla-Val Model 90-01.
b. Design:
1) Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
2) Rated for the test pressure of the corresponding piping system, as specified in the Piping Schedule.
3) Downstream pressure adjustment range: 30 to 300 psig.
4) Pilot line: Equipped with a strainer.
5) Flanges: Class 150, in accordance with ASME B16.42.
c. Materials:
1) Body and cover: Ductile Iron ASTM A536.
2) Valve trim: Bronze.
3) Pilot control: Cast bronze with Type 316 stainless steel trim.
4) Diaphragm: Nylon reinforced Buna N.

F. Oil/water separator:
   1. Manufacturers: One of the following or equal:
      a. Highland Tank and Manufacturing Co., Similar Series.
      b. PARK Oil Tropper Series, CMP-400.
      c. Pan America Environmental, Similar Series.
   2. An oil/water separator shall be furnished and installed in the location as indicated on the Drawings.
   3. The sizing of the oil/water separator shall be consistent with protocols for complying with the minimum federal spill and discharge regulations. The free oil and grease concentration in the effluent from the separator shall not exceed 10 mg/L.
   4. Oil/water separator shall be a rectangular, Class II concrete with a design strength of 4,500 pounds per square inch at 28 days.
      a. Unit is monolithic construction at floor and first stage of wall with sectional riser to required depth as indicated on the Drawings.
      b. Rated for H-20 Loading.
      c. Grade 60 reinforced, No. 4 steel rebar in accordance with ASTM A615 on required centers or equal.
      d. Bar bending and placement shall in accordance with the latest ACI standards.
      e. Cast iron rings and grates are manufactured of grey cast iron in accordance with ASTM A48 Class 30.
      f. Shall have the structural strength to withstand static and dynamic hydraulic loading while empty and during operating conditions.
      g. Unit shall be sized for an influent flowrate of 40 gpm of non-emulsified oil/water mixtures from building drainage from diesel fuel spills, and/or cleaning and maintenance operations.
   5. The oil/water separator shall be provided with the following outlets:
      a. One 4-inch threaded inlet connection at the inlet end of the separator.
      b. One 4-inch flanged effluent connections at the outlet end of the separator.
      c. One 4-inch flanged vent connection on the side of the separator.
      d. Fittings for vent, level sensor, waste-oil pump out, sampling, and gauge.
      e. Single-piece 24-inch diameter cover to provide complete closure of the tanks, mounted via quick release hardware and vapor-sealed with D shaped compressible EPDM gasket.
   6. Level switches. The oil/water separator manufacturer shall supply intrinsically safe level switches for their equipment as follows:
      a. High oil level.
      b. High-high oil level.
      c. Level switches shall be intrinsically safe design with Type 316 stainless steel floats.
   7. Control panel:
      a. The oil/water separator manufacturer shall supply a completely factory wired control panel for monitoring and alarms.
      b. The panel enclosure shall be NEMA 4X Type 316 stainless steel.
      c. Panel shall be constructed to UL standards and shall bear a UL label.
      d. Minimum AIC rating shall be 10,000A.
      e. Panel shall have a local power disconnecting means to turn off all power to the panel for modification, inspection, or repair.

f. Furnish and install accessories as required for free standing mounting on stainless steel posts.
    1) Indication lights: Panel mounted indication lights and legend plates for the following:
        a) Power on.
        b) High oil level.
        c) High-high oil level.
        d) Visual alarm:
            (1) The panel shall include a flashing red strobe-type light.
            (2) The visual alarm will be activated by the High Oil Level switch or the High-High Oil Level switch.
        e) Audible alarm:
            (1) The panel shall include a panel mounted alarm bell or horn with adjustable volume control up to 101 dB at 10 feet.
            (2) The audible alarm will be activated by the High-High Oil Level switch.
        f) Push buttons: Silence control for the audible alarm.
    2) Power: Power to the control panel shall be 120 volt, 1 phase.
    3) Provide sufficient wiring to allow installation of panel as indicated on the Drawings.
    4) Manufacturer shall provide minimum 2-year warranty that product will operate as specified and be free of defects in material and workmanship from the date of acceptance by Engineer.

## 2.05 DRAIN, WASTE, AND VENT PIPING

A. Cast iron soil pipe:
    1. Bell-and-spigot service weight in accordance with ASTM A74.
        a. "No Hub" optional for above ground.
    2. Joints underground: positive double seal compression type gaskets in accordance with ASTM C564.
    3. Joints aboveground:
        a. American standard taper screw threads cut clean and made up with Teflon™ tape or an acceptable paste thread compound applied to the male threads only.
        b. Slip joints permitted only in trap seals or on the inlet side of the traps.
            1) Do not use long screws or bushings.
    4. Cast iron drainage pattern fittings.
    5. Couplings for "No Hub": Stainless steel corrugated shield and clamp assembly over a molded 1-piece neoprene sealing sleeve, in accordance with ASTM A888.
    6. Line pipe and fittings inside and coat outside with bituminous coating except as follows:
        a. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

B. PVC:
    1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
        a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 B material in accordance with ASTM D1784.

b. PVC Pipe: Schedule 40 unless otherwise indicated on the Drawings.

2. Fittings:
   a. Supplied by pipe manufacturer.
   b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
   c. DWV fittings: In accordance with ASTM D2665.
3. Solvent cement: In accordance with ASTM D2564:
   a. Chemical service: For PVC pipe in chemical service, provide the following primer and cement, or equal:
      1) Primer: IPS Corp Type P-70™.
      2) Cement: IPS Corp Type 724™ cement or cement certified by the manufacturer for chemical service.

## 2.06 POTABLE COLD, HOT, TEPID, AND COMPRESSED AIR/WATER PIPING

A. Seamless copper water tube:
   1. Type: ASTM B88:
      a. Exposed copper piping or tubing: Type L hard-drawn, rigid.
      b. Copper tubing buried in the ground or in plastic conduit: Type K soft annealed.
   2. Fittings: Solder type forged or wrought copper.
      a. Manufacturers: One of the following or equal:
         1) Crawford Fitting Co., Swagelok.
         2) Hoke, Gyrolok.
         3) Parker.
   3. Solder:
      a. Filler: ASTM B32, Alloy Grade Sb5.
      b. Flux: ASTM B813.
   4. Brazing:
      a. Filler: BCuP series, sopper phosphorus alloys for general duty brazing conforming to AWS A5.8M/A5.8.
   5. Dielectric insulating unions or fittings:
      a. Manufacturers: One of the following or equal:
         1) Mueller Co.
         2) Watts Series 3001A.
   6. Special thread to tube adapters:
      a. Manufacturers: One of the following or equal:
         1) Crawford Fitting Co., Swagelok.
         2) Hoke, Gyrolok.
         3) Parker.

B. Compressed Air System Piping Accessories:
   1. Spring Retractable Hose Reels:
      a. Manufacturer, the following or equal:
         1) Reelcraft, model DP7800
         2) Coxreels, similar model.
      b. Hose Size: 1/2 inch and 50 foot length; or as indicated on drawings.
      c. Hose Type: PVC nylon braid hose rated for 250 psi pressure.
      d. Construction:
         1) All steel construction with powder coating for corrosion protection.
         2) Dual pedestal base for structural mounting.

2. Quick Connect Couplings:
    a. Construction:
        1) Brass for copper piping systems.
        2) Stainless steel for stainless steel piping systems.
    b. Size to match pipe size or as indicated on drawings.
    c. Manufacturer, the following or equal:
        1) Parker.
        2) Eaton Hansen.

C. Aluminum tubing:
1. Aluminum tubing: Alloy 6061-T6 in accordance with ASTM B210.
2. Diameter: Not less than 1/4-inch, with wall thickness not less than 0.035-inch.
3. Provide swage type fittings as follows:
    a. By swaging generate a bowed effect in tubing ahead of the 2 ferrules to produce in 2 secondary seals, between tube end and shoulder in the fitting body, and between the enlarged section of tubing and the throat of the fitting body.
    b. Accomplish primary seal by a metal-to-metal contact between the taper of the fitting body and the front ferrule.
    c. Fittings: Standard tube fittings made of aluminum alloy, suitable for the specified test pressures.

## 2.07 NATURAL GAS PIPING

A. Steel pipe:
1. In accordance with ASTM A53.
2. Type: Type E - electric-resistance welded or Type S - seamless.
3. Grade: Grade A or B.
4. Schedule 40.
5. Pipe fittings:
    a. Screwed fittings:
        1) Malleable iron:
            a) Class 150 or Class 300 in accordance with ASME B16.3, as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
            b) Galvanized in accordance with ASTM A153 where used with galvanized pipe.

## 2.08 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.

## 2.09 PIPE INSULATION

A. General:
   1. As specified in Section 01600 - Product Requirements.
   2. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

**Table 1 - Required Insulation Thicknesses (inches)**

| Service Temperature Range as Designated in Insulation Schedule at End of this Section | Nominal Pipe Diameters | | | | |
|---|---|---|---|---|---|
| | 1 inch and Less | 1.25 to 2 inches | 2.5 to 4 inches | 5 to 10 inches | Over 10 inches |
| Above 200 degrees Fahrenheit | 2.0 | 2.5 | 3.0 | 3.5 | 3.5 |
| 100 to 200 degrees Fahrenheit | 1.5 | 1.5 | 1.5 | 2.0 | 2.5 |
| 40 to 100 degrees Fahrenheit | 0.5 | 1.0 | 1.0 | 1.5 | 2.0 |
| Below 40 degrees Fahrenheit | 1.0 | 1.0 | 1.5 | 2.0 | 2.0 |
| Heat Traced Pipes | 1.0 | 1.0 | 1.0 | 1.5 | 2.0 |

B. Insulation, Type 1:
   1. Insulation material: Closed cell elastomeric insulation.
   2. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
   3. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet-degrees Fahrenheit.
   4. Fire ratings:
      a. Flame spread: 25 or less.
      b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
   5. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.
   6. Manufacturers: One of the following or equal:
      a. Aeroflex USA Inc., Aerocel® AC.
      b. Armacell®, AP Armaflex.

C. Insulation, Type 2:
   1. Insulation material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
      a. In accordance with ASTM C547, Class 1.
      b. Provide with factory installed vapor barrier.
         1) Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type I.
         2) Longitudinal lap seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.

3) Circumferential butt seals: 4-inch-wide tape or similar properties or 4-inch-wide overlap with adhesive seal.
4) Vapor barrier permeability: 0.02 perms or lower.
5) Vapor barrier flame spread rating: 25 or less.

2. Minimum temperature range: Minus 0 degrees Fahrenheit to plus 850 degrees Fahrenheit.
3. K factor at 75 degrees Fahrenheit: Not more than 0.23 BTU-inch/hour-square feet degrees Fahrenheit.
4. Maximum moisture absorption, volume percent: 5.
5. Manufacturers: One of the following or equal:
   a. Owens-Corning, Fiberglas™ FLEXWRAP® ASJ
   b. Johns Manville, Micro-Lok® HP.
   c. Knauf Insulation, Earthwool® Redi-Klad® 1000° Pipe Insulation.

D. Insulation jackets:
1. Type 1:
   a. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
   b. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
   c. Color: White.
   d. Overlap: 1-inch minimum at joints and fittings.
   e. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
   f. Fittings: Factory made with full thickness insulation.
   g. Manufacturers: One of the following or equal:
      1) Johns Manville, Zeston® 2000 PVC.
      2) Proto Corp., LoSMOKE PVC.
      3) Speedline® Corp., Smoke-Safe™ PVC.
2. Type 2:
   a. Material: Aluminum, Alloy 5005; 0.016-inch (26-gauge) minimum thickness.
   b. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
   c. Bands: 0.5-inch wide, 0.0508-inch (16-gauge) thick aluminum, same alloy as jacket or 0.0179-inch-thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
   d. Joint seal: Apply waterproof adhesive at joints and overlaps.
   e. Fittings: Custom fit of same materials.
   f. Manufacturers: One of the following or equal:
      1) Childers Products.
      2) Premetco International.

E. Vapor barriers:
1. Vapor barrier, Type 1:
   a. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
   b. Permeability: 0.02 perms or lower.
   c. Maximum flame spread rating: 25.
   d. Edge seal: Pressure-sensitive tape lap seal.

e. Circumferential joints: 4-inch-wide tape or 4-inch overlap with adhesive seal.

2. Vapor barrier, Type 2:
   a. Material: Mastic.
   b. Manufacturers: One of the following or equal:
      1) Benjamin Foster, No. 30-76.
      2) Childers Products CP10/11 Vi-Acryl.
      3) Foster Products, 36-10/46-10 Weatherite.
      4) Insul-Coustic, No. I.C.-580.

F. Insulation schedule:

**Table 2 - Insulation Schedule**

| Service Designation[1] | Location[2] | Insulation Type[3] | Jacket Type[3] | Service Temp. °F[4] | Vapor Barrier |
|---|---|---|---|---|---|
| Hot Water | Interior or Exterior | 1 or 2 | Type 1 on Exterior installations, none required on Interior installations | 100-200 | Install on Type 2 insulation |
| Heat Traced Pipes[5] | Exterior | 1 or 2 | 2 | N/A | Install on Type 2 insulation |

Notes:
1. Refer to Piping Schedule in Section 15052 - Common Work Results for General Piping for service designations.
2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
3. Contractor may select from options listed.
4. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table 1.
5. Insulate all piping systems that are heat traced as indicated on the Drawings.

## PART 3 EXECUTION

### 3.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. As specified in Section 15082 - Piping Insulation.

C. Conceal plumbing piping unless otherwise indicated on the Drawings or specified in the specifications.

D. Furnish and install vents required in drainage piping as part of the plumbing system, in accordance with Laws and Regulations.

E. Use Link Type Seals as indicated on the Drawings.

## 3.02 INSTALLATION

A. Fixtures:
   1. Rough-in fixtures and accessories in accordance with the dimensions supplied by the manufacturers of the fixtures.
   2. Mount fixtures and accessories without cutting of finish surface.

B. Plumbing and drainage products:
   1. Backflow preventers:
      a. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.
      b. Install with sufficient side clearance for access for testing and maintenance.
   2. Provide cleanouts of the same size as the size of the waste and drain piping on which cleanouts are installed, up to 4 inches in diameter. Provide cleanouts 4 inches in diameter on waste and drain piping larger than 4 inches diameter.
   3. Provide traps at all fixture and equipment connections to the sanitary drainage system. Install traps as near to the fixtures as possible.
   4. Sizes of equipment drains and of floor drains shall be as indicated on the Drawings.
   5. When indicated on the Drawings, cut holes in heavy-duty floor drain grate for a drainpipe from equipment or other source.

C. Equipment:
   1. As specified when applicable in Section 15050 - Common Work Results for Mechanical Equipment.
   2. Provide piping for drain and overflow connections to drains.

D. Drain, waste, and vent piping:
   1. As specified when applicable in Section 15052 - Common Work Results for General Piping.
   2. Where not specified otherwise, install horizontal piping with a grade of 1/4 inch per foot.
   3. Provide vents, roof drains, and pipes flashed and made watertight at the roof with lead sheet flashings.
      a. Minimum 4-pound lead sheet.
   4. Extend flashing not less than 6 inches up the pipes, and counterflash with standard cast iron or malleable iron recessed roof couplings.
   5. Extend flashing for vents up to the top of the vent and turn down into the pipe.
   6. Extend flashing shields not less than 8 inches from vent and pipe in all directions.

E. Potable cold, hot, and tepid water piping:
   1. Install copper tubing in accordance with ASTM B828 and IAPMO IS 03.
   2. Install copper tubing in straight runs, supported at intervals close enough to avoid sagging.
   3. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
      a. Provide a sizing tool to correct distortions.

4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
5. Perform flaring with a flare block and yoke type screw feed flaring tool:
    a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
    b. Where there are imperfections, cut off the imperfect flare, and prepare a new flare.
6. Insulate piping as specified.

## 3.03 FIELD QUALITY CONTROL

A. Testing:
1. Test soil, waste, drain, and vent lines as specified and in accordance with plumbing code as specified in Section 01410 - Regulatory Requirements.
2. Test water piping with water under a pressure of 100 psig.
    a. As required per code.
3. Repair and correct defective work disclosed by testing. Repeat testing until defective work is corrected.

## 3.04 CLEANING AND DISINFECTION

A. Upon completion of installation, clean piping interior of foreign matter and debris.

B. Flush and disinfect potable water piping as specified in Section 01757 - Disinfection.

## 3.05 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
1. Provide certificates:
    a. Manufacturer’s Certificate of Installation and Functionality Compliance.

C. Functional testing:
1. Backflow preventer:
    a. Test witnessing: Witnessed.
    b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.
    c. Backflow preventer certification.

## 3.06 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

## SECTION 15956

## 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 15052 - 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 01410 - Regulatory Requirements, and UL requirements.
   4. Test natural gas or digester gas piping:
      a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
      b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
   5. When testing with water, the specified test pressure is considered to be the pressure at the 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. Water for testing, cleaning, and disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01500 - Temporary Facilities and Controls.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal: Dispose of testing water 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 01330 - 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.

B. Deflection test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
   3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

### 3.02 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 15052 - 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:

      $L = S \times D \times P^{1/2} \times 133{,}200^{-1}$

      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 15052 - 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.

E. Optional joint test:
   1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
      a. Joint testing will be allowed only for low head pressure piping.
      b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.
   2. Joint testing may be performed with water or air.
   3. Joint test piping after completion of backfill and compaction to the top of the trench.
   4. Joint testing with water:
      a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
      b. Maintain test pressure for 1 minute.
      c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
      d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
      e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
   5. Joint testing with air:
      a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
      b. Maintain test pressure for 2 minutes.
      c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

# SECTION 15958

# MECHANICAL EQUIPMENT TESTING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

### 1.02 REFERENCES

A. American National Standards Institute (ANSI):

1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

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

### 1.03 SUBMITTALS

A. Provide Source Test Plans as specified in Section 01756 - Commissioning.

B. Provide Installation and Functional Testing Plans as specified in Section 01756 - Commissioning.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals.
1. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

### 3.01 GENERAL

A. Commissioning of equipment as specified in:
1. This Section.
2. Section 01756 - Commissioning.
3. Equipment sections:
   a. If testing requirements are not specified, provide Level 1 Tests.

B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.

C. Operation of related existing equipment:
1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.
2. Schedule and coordinate testing as required by Section 01756 - Commissioning.

D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

E. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy.
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

## 3.02 VARIABLE SPEED EQUIPMENT TESTS

A. Establish performance over the entire speed range and at the average operating condition.

B. Establish performance curves for the following speeds:
   1. The speed corresponding to the rated maximum capacity.
   2. The speed corresponding to the minimum capacity.
   3. The speed corresponding to the average operating conditions.

## 3.03 PUMP TESTS, ALL LEVELS OF TESTING

A. Test in accordance with the following:
   1. Applicable HI Standards.
   2. This Section.
   3. Equipment sections.

B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
   1. From 0 to plus 5 percent of head at the rated design point flow.
   2. From 0 to plus 5 percent of flow at the rated design point head.
   3. No tolerance for head and flow when ranges are specified.
   4. No negative tolerance for the efficiency at the rated design point, and other specified conditions.
   5. Use of specified test tolerances shall not result in motor overload while operating at any point on the supplied pump operating head-flow curve, including runout.
   6. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

## 3.04 DRIVERS TESTS

A. Test motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

B. Test other drivers as specified in the equipment section.

## 3.05 NOISE REQUIREMENTS AND CONTROL

A. Perform noise tests in conjunction with vibration test analysis.

B. Make measurements in relation to reference pressure of 0.0002 microbar.

C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

D. Set sound level meter to slow response.

E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

## 3.06 PRESSURE TESTING

A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

## 3.07 INSPECTION AND BALANCING

A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.

C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

D. Critical speed of rotating equipment:
   1. Satisfy the following:
      a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
      b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
      c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

E. Vibration tests:
   1. Definitions:
      a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
      b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.
      c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
      d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
      e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
         1) Manufacturers: One of the following or equal:
            a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
            b) CSI, "PeakVue."
      f. Rotor bar pass frequency (RBF), for detecting loose rotor bars.
      g. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
      h. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
      i. Preferred operating range: Manufacturer’s defined preferred operating range (POR) for the equipment.
      j. Allowable operating range: Manufacturer’s defined allowable operating range (AOR) for the equipment.
   2. Vibration instrumentation requirements:
      a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
         1) Manufacturers: One of the following or equal:
            a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
            b) Pruftechnik, VIBXPERT II.
      b. Analyzer settings:
         1) Units: English, inches/second, mils, and gravitational forces.
         2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low-speed equipment.
         3) Sample averages: 4 minimum.

4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
6) Fast fourier transform windowing: Hanning Window.
7) High pass filter: Minus 3 dB at 120 cycles per minute for high-speed equipment. Minus 3 dB at 21 cycles per minute for low-speed equipment.

c. Accelerometers:
1) For low-speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 797L.
(2) PCB, Model 393C.
2) For high-speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 793.
(2) Entek-IRD Model 943.

3. Accelerometer mounting:
a. Use magnetic mounting or stud mounting.
b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.

4. Vibration acceptance criteria:
a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

| Operating Conditions and Application Data | Overall Peak-to-Peak Displacement | |
|---|---|---|
| | Field, mils | Factory, mils |
| **Operation within the POR** | 3.0 | 4.0 |
| **Operation within the AOR** | 4.0 | 5.0 |
| Additive value when measurement location is greater than 5 feet above foundation. | 2.0 | 2.0 |
| Additive value for solids-handling pumps | 2.0 | N/A |
| Additive value for slurry pumps | 2.0 | N/A |

c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

| HI Pump Type | Horsepower | Field Test Overall RMS | Factory Test Overall RMS |
|---|---|---|---|
| Horizontal Solids Handling Centrifugal Pumps | Below 33 hp | 0.25 | 0.28 |
| Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type) Vertical Solids Handling Centrifugal Pumps | Between 33 and 100 hp | 0.28 | 0.31 |
| | 100 hp and above | 0.31 | 0.34 |
| | Below 33 hp | 0.30 | 0.33 |
| Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps) | Between 33 and 100 hp | 0.32 | 0.35 |
| | 100 hp and above | 0.34 | 0.35 |
| Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7 | Below 268 hp | 0.15 | 0.19 |
| | 268 hp and above | 0.19 | 0.22 |
| Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8 | Below 268 hp | 0.13 | |
| | 268 hp and above | 0.17 | |
| Slurry Pumps | | 0.25 | 0.30 |
| Motors | | See Applicable Motor Specification | See Applicable Motor Specification |
| Gear Reducers, Radial | | Not to exceed AGMA 6000-B96 limits | Not to exceed AGMA 6000-B96 limits |
| Other Reducers, Axial | | 0.1 | N/A |

d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

e. Additional criteria:

1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.

2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
3) For motors, the following shall be cause for rejection:
    a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
    b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
    c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
    d) Phasing problems evidenced by 1/3-line frequency side band spectral peaks around the 2 times electrical line frequency peak.
4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

5. Vibration testing results presentation:
    a. Provide equipment drawing with location and orientation of measurement points indicated.
    b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
    c. When Vibration Spectra Data required:
        1) Plot peak vibration velocity versus frequency in cycles per minute.
        2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
        3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
        4) Plot motor spectra on a log amplitude scale versus frequency.
    d. For low-speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
    e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

## 3.08 TESTING LEVELS

A. Level 1 Tests:
   1. Level 1 Performance Test:
      a. General:
         1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
         2) Operate at rated design load conditions.
         3) Confirm that equipment is properly assembled.
         4) Confirm the equipment moves or rotates in the proper direction.
         5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
         6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
      b. Pumps:
         1) Comply with general performance test requirements as specified in this Section.
         2) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
            a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower or the applicable equipment section.
            b) Use actual driver for field tests.
         3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
   2. Level 1 Vibration Test:
      a. Test requirement:
         1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
         2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
      b. Equipment operating condition: Test at specified maximum speed.
   3. Level 1 Noise Test:
      a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Tests:
   1. Level 2 Performance Test:
      a. General:
         1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
         2) Operate at rated design load conditions.
         3) Confirm that equipment is properly assembled.

4) Confirm the equipment moves or rotates in the proper direction.
5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:
1) Comply with general performance test requirements as specified in this Section.
2) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
b) Use actual driver for field tests.
3) Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

2. Level 2 Vibration Test:
a. Test requirement:
1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.

b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.

c. Natural frequency test of field installed equipment:
1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
3) Perform with equipment and attached piping full of intended service or process fluid.

3. Level 2 Noise Test:
a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Tests:
1. Level 3 Performance Tests:
a. General:
1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
3) Confirm that equipment is properly assembled.
4) Confirm the equipment moves or rotates in the proper direction.
5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
8) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.
b. Pumps:
1) Comply with general performance test requirements as specified in this Section.
2) Test 4 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test at full speed.
a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
b) Use actual driver for field tests.
3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
5) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.

b) Perform efficiency testing with test fluids at maximum rated speed.
c) Perform priming time testing with test fluids at maximum rated speed.

2. Level 3 Vibration Test:
   a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
   b. Perform High Frequency Enveloping Analysis for gears and bearings.
      1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
      2) Report results in units of acceleration versus frequency in cycles per minute.
   c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
   d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
3. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Tests:
1. Level 4 Performance Test:
   a. General:
      1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
      2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
      3) Confirm that equipment is properly assembled.
      4) Confirm the equipment moves or rotates in the proper direction.
      5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
      6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
      7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
      8) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

b. Pumps:
    1) Comply with general performance test requirements as specified in this Section.
    2) Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
    3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
    4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
    5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
    6) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
        a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
        b) Perform efficiency testing with test fluids at maximum rated speed.
        c) Perform priming time testing with test fluids at maximum rated speed.

2. Level 4 Vibration Test: Same as Level 3 vibration test.
3. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION

## SECTION 16050

## COMMON WORK RESULTS FOR ELECTRICAL

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Requirements for electrical:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation.

B. Contract Drawings:

   1. Plan drawings:
      a. Electrical drawings show desired locations, arrangements, and components of the electrical Work in a diagrammatic manner.
      b. Locations and sizes of equipment are approximate only.
   2. Installation details:
      a. Contract Drawings include typical installation details the Contractor is to use to complete the electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      b. Not all typical installation details are referenced within the drawing set. Apply and use typical details where appropriate.

### 1.02 REFERENCES

A. Abbreviations:
   1. ICSC: Instrumentation and controls subcontractor.
   2. PCIS: Process control and instrumentation system.

B. Standards:
   1. American National Standards Institute (ANSI).
   2. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   3. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL).

### 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. LCP: Local control panel: Operator interface panel that may contain pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.

2. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
3. Space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment.
    a. Furnish hardware to accommodate installation of future circuit breakers, instruments, relays, and controls.
    b. Wire relay and circuit breaker control power and network connections to the compartment and provide terminations.
    c. Space for future devices shall include:
        1) All necessary bus.
        2) Device supports and mounting equipment.
        3) Device connections to bus work.
        4) Wire troughs or raceway space.
4. Spare: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
5. Unequipped space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
6. Vendor control panel (VCP): Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

## 1.04 DELEGATED DESIGN

A. Requirements for Delegated Design are specified in the Technical Sections.

## 1.05 SUBMITTALS (NOT USED)

## 1.06 QUALITY ASSURANCE

A. General:
    1. Furnish equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

## 1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

## 1.08 ADMINISTRATIVE REQUIREMENTS

A. Meetings:
    1. As specified in Section 01312 - Project Meetings.

## PART 2 PRODUCTS

### 2.01 GENERAL (NOT USED)

### 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide field wiring and terminations.

### 2.03 MANUFACTURERS (NOT USED)

### 2.04 MATERIALS

A. Enclosures:
   1. Provide enclosures for electrical, instrumentation, and control equipment, regardless of Supplier or Subcontractor furnishing the equipment, that meet the requirements of NEMA Standard 250.
      a. Provide metallic enclosures unless specifically indicated otherwise.

B. Stainless steel:
   1. Where stainless steel is indicated or used for any portion of the electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.

C. Plant area electrical work requirements:
   1. Provide electrical materials in accordance with the following table, unless otherwise specifically indicated on the Drawings:
      a. Conduit installation requirements: As specified in Section 16130 - Conduits.

**Table 1. Electrical Material Requirements**

| Plant Area | Environment: W = Wet D = Damp C = Clean/dry X = Corrosive H = Hazardous | NEMA Enclosure Type | Exposed Conduit Type (as specified in Section 16130 - Conduits) | Support Materials |
|---|---|---|---|---|
| Process Area | D | 4X SST | PCS | SST |
| Electrical Room | C | 12 | GRC | GALV STL |

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
   1. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work.

2. Determine information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
3. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.

## 3.02 PREPARATION (NOT USED)

## 3.03 INSTALLATION

A. Demolition:
   1. As specified in Technical Sections or as indicated on the Drawings.
   2. Disconnect utilities:
      a. Disconnect electrical equipment.
      b. Disconnect other utilities as specified in Section 16210 - Utility Coordination.
   3. Remove and dispose of conduit, wire, electrical equipment, controls, etc., associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
   4. For each piece of equipment to be removed, remove ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
   5. Conduit:
      a. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
         1) Remove exposed conduit to the point of encasement or burial.
         2) Cut conduit flush and plug or cap encased or buried conduit.
      b. Where conduits are to remain in place and removal is not indicated on the Drawings:
         1) Cap conduit open ends.
         2) Re-label empty conduits as spare.
   6. Remove wire back to the source for conduits to be removed or abandoned in place.
   7. Provide new nameplates for modified electrical distribution equipment, motor control centers etc., to identify equipment and circuits that are no longer used as spares.
   8. Provide new typewritten schedules for modified panelboards.

B. Equipment:
   1. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.

C. Provide NEC required working space in front of electrical equipment as if it could be worked on energized.

## 3.04 FIELD QUALITY CONTROL

A. Workmanship:
   1. Leave wiring in panels, boxes, and other locations neat, clean, and organized:
      a. Neatly coil and label spare wiring lengths.
      b. Shorten, re-terminate, and re-label excessively long used, as well as spare, wire and cable lengths, as directed by the Engineer.

B. Inspection activities conducted during construction do not satisfy the inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.

C. Provide on-site assistance for troubleshooting and correcting electrical issues discovered during installation and testing for the Project.

## 3.05 OWNER TRAINING (NOT USED)

## 3.06 ADJUSTING (NOT USED)

## 3.07 CLEANING

A. General:
   1. Clean and vacuum enclosures to remove metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
      a. Use of compressors or air blowers for cleaning is not acceptable.
   2. Clean luminaries in the areas affected by the construction.

END OF SECTION

## SECTION 16060

## GROUNDING AND BONDING

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Grounding materials and requirements.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

### 1.03 DELEGATED DESIGN (NOT USED)

### 1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.

### 1.05 QUALITY ASSURANCE

A. Grounding components and materials shall be UL listed and labeled.

### 1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

### 1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

### 1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

# PART 2 PRODUCTS

## 2.01 GENERAL (NOT USED)

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Ground equipment and raceway systems so that the completed installation is in accordance with applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Ground connections.

## 2.03 MANUFACTURERS

## 2.04 MATERIALS (NOT USED)

## 2.05 EQUIPMENT (NOT USED)

## 2.06 COMPONENTS (NOT USED)

## 2.07 ACCESSORIES (NOT USED)

# PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 PREPARATION (NOT USED)

## 3.03 INSTALLATION

A. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

B. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
   1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

C. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

D. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

E. Shield grounding:
   1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
   3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
   4. Terminate the signal cable shield on a dedicated grounding terminal block.

END OF SECTION

# SECTION 16070

# HANGERS AND SUPPORTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Mounting and supporting electrical equipment and components.

### 1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

### 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. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
   2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
   3. Supports: Preformed channel or other structural member on which the electrical equipment or raceway is mounted.

### 1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

### 1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Supports:
      a. Materials.
      b. Geometry.
      c. Manufacturer.
   2. Hardware:
      a. Materials.
      b. Manufacturer.

C. Shop Drawings:
   1. Dimensioned and scalable Shop Drawings of hangers and supports for raceway systems and equipment.
   2. Complete details for:
      a. Member sizes and arrangement in hangers and support assemblies.
      b. Connections between members in hangers and support assemblies.
      c. Anchoring hangers and supports to structures.
      d. Bracing for hangers and supports and anchoring of bracing to structures.
   3. Include data on connections, attachment hardware and construction to demonstrate that hangers and supports will satisfy the design loading, bracing, and anchoring criteria.

D. Delegated Design Submittals:
   1. Hangers and supports - General:
      a. Locations and conditions:
         1) Hangers and supports inside structures.
         2) Hangers and supports that resist cable pulling/rigging loads.
      b. Required Submittals: Details with supporting calculations for:
         1) Support member arrangement, sizes, and connections.
         2) Bracing to resist cable pulling/rigging loads.
         3) Connections of hangers, supports, and bracing to the structure.
         4) Connections between supports and the equipment or raceway(s) thereon.
   2. Hangers and supports - Seismic conditions:
      a. Locations and conditions:
         1) Hangers and supports at structures designated as seismic design category (SDC) C, D, E, or F in Section 01850 - Design Criteria.
         2) Hangers and supports for outdoor installations.
      b. Required Submittals:
         1) Interior: Bracing to resist seismic design loads specified in Section 01850 - Design Criteria.
   3. Hangers and supports anchored to concrete and masonry:
      a. Locations and conditions:
         1) Post-installed mechanical anchors in tension.
         2) Post-installed adhesive-bonded all-thread rods in tension.
      b. Required Submittals:
         1) Calculations demonstrating that anchors have a demand/capacity ratio (D/C) not greater than the following when anchor capacity is adjusted for moisture conditions, anchor spacing and edge distances, and sustained loading conditions present at the location of installation.
            a) Post-installed mechanical anchors maximum: 85 percent.
            b) Post-installed adhesive-bonded anchors maximum: 75 percent.

## 1.06 QUALITY ASSURANCE (NOT USED)

## 1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

## 1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

## 1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. Mount raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated supports unless otherwise indicated on the Drawings.

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Hangers and supports individually and as a system shall resist weights and code-required forces without deflections and deformations that would damage the supporting elements, the raceway or equipment supported, or the surrounding construction.
   1. Provide the necessary sway bracing to keep support structures from swaying due to lateral forces, including wire and cable pulling forces.
   2. Lateral deflection at top of slab mounted supports shall not exceed support height divided by 240, unless otherwise approved by the Engineer.

## 2.03 MANUFACTURERS

A. One of the following or equal:
   1. Preformed channel:
      a. Eaton B-line.
      b. Power-Strut.
      c. Robroy.
      d. Tyco.
      e. Unistrut.

## 2.04 MATERIALS

A. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A123 or A153.
      b. Minimum zinc coating thickness of 2.5 mils.
      c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
   2. Hardware:
      a. Electro-galvanized.
      b. In accordance with ASTM A153.

B. Stainless steel:
   1. Supports:
      a. In accordance with ASTM A240.
      b. ANSI Type 316 material.
      c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.

2. Hardware:
    a. ANSI Type 316 material.

## 2.05 MANUFACTURED UNITS (NOT USED)

## 2.06 EQUIPMENT (NOT USED)

## 2.07 COMPONENTS

A. Fabricated metal supports: As specified in Section 05500 - Metal Fabrications.

## 2.08 ACCESSORIES

A. Anchors: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

## 2.09 FABRICATION (NOT USED)

## 2.10 FINISHES

A. Paint and finish structures: As specified in Section 09960 - High-Performance Coatings.

# PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 PREPARATION

A. Anchoring and bracing to structures:
    1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
    2. Install anchors of type and material indicated on approved anchoring designs.
    3. Install anchors with embedment indicated on approved anchoring designs.

## 3.03 INSTALLATION

A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.

B. General:
    1. Refer to the Drawings for details. Equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
    2. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

C. Corrosion protection:
    1. Isolate dissimilar metals, except where required for electrical continuity.
        a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

D. Anchoring methods:
   1. Solid concrete:
      a. Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Metal surfaces: Machine screws or bolts.
   3. Hollow masonry units:
      a. Post installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   4. Wood and metal studs:
      a. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

E. Recoat or seal drilled holes, or cut/scratched surfaces with products recommended by the manufacturer.

F. Group raceway and position on racks to minimize crossovers.

END OF SECTION

## SECTION 16075

## IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices and components.
   2. Material, manufacturing and installation requirements for identification devices.

### 1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

B. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

C. Occupational Safety and Health Administration (OSHA).

### 1.03 DELEGATED DESIGN (NOT USED)

### 1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers, including spares and destination points for all wires.

### 1.05 QUALITY ASSURANCE (NOT USED)

### 1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

## 1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

## 1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

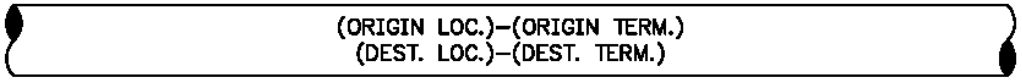
# PART 2 PRODUCTS

## 2.01 GENERAL

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Nameplates:
   1. Provide for each piece of electrical equipment and modified MCC bucket.
   2. Identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Equipment tag number as indicated on the Drawings.

B. Wire numbers:
   1. Coordinate the wire numbering system with vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. Multi-conductor and instrumentation cables shall be identified at pull points as described above:
   2. Provide the following wiring numbering schemes throughout the Project for field wires between process control module (PCM), vendor control panels (VCP), motor control centers (MCC), field starters, field instruments, etc.


OR:

Where:

ORIGIN LOC. = Designation for originating panel or device

ORIGIN TERM. = Terminal designation at originating panel or device

DEST. LOC. = Designation for destination panel or device

DEST. TERM. = Terminal designation at destination panel or device or PLC

3. I/O address at destination panel:
   a. Identify equipment and field instruments as the origin.
   b. PCMs are always identified as the destination.
   c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
   d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
   e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g., T1, T2, T3, etc.).
   f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: The following PLC I/O numbering scheme is typical for Allen-Bradley. The numbering scheme should be modified to match that of the actual PLC manufacturer used for the Project):

      Discrete Point: W:X:Y/Z.

      Analog Point: W:X:Y.Z.

      Where:

      W = I for input, O for output.

      X = PLC number (1, 2, 3…)

      Y = Slot number (01, 02, 03…)

      Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

   g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g., C0010A).
4. **Case 1**: Vendor control panel (VCP) to process control module (PCM):

   Field wire number/label: A-B/C-D:

   A = Vendor control panel number without hyphen (VCP#)

   B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)

   C = Process control module number without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples:

VCP#-10/PCM#-I: 1:01/01

VCP#-10/PCM#-O: 1:10/07

VCP#-10/PCM#-C0100

5. **Case 2**: Field instrument to process control module (PCM) or vendor control panel (VCP):

   Field wire number/label: E-F/C-D:

   C = Process control module number without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)

   E = Field mounted instrument tag and loop numbers without hyphen (EDV#)

   F = Manufacturer’s standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

   Examples:

   TIT#-2,3/PCM#-I: 1:01.1

   TSH#-1/PCM#-I: 2:01/00

6. **Case 5**: Motor leads to a motor control center (MCC):

   Field wire number/label: H-I/G-B:

   B = Terminal number within motor control center (manufacturer’s standard terminal number)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   H = Equipment tag and loop number without hyphen (PMP#)

   I = Motor manufacturer’s standard motor lead identification (e.g., T1, T2, T3, etc.)

   Example:

   PMP-#-T3/MMS#-T3

7. Identify spare conductors as required for other field wires with an “S” prefix:

   Example:

   S MMS#-10/PCM#-C011

## 2.03 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

B. Conductor and cable markers:
   1. Heat-shrinkable tubing:
      a. One of the following or equal:
         1) Brady.
         2) Kroy.
         3) Panduit.
         4) Raychem.
   2. Pre-printed slip-on sleeve markers:
      a. The following or equal: Engineer knows of no equal.
         1) Grafoplast.

C. Conduit and raceway markers:
   1. Non-metallic: One of the following or equal:
      a. Almetek: Mini Tags.
      b. Lapp Group: Maxi System.

## 2.04 MATERIALS

A. Nameplates:
   1. Colors:
      a. Warning: White-center, red face.
      b. Other: Black-center, white face.
   2. Laminated plastic engraving stock:
      a. 1/16-inch thick material.
      b. 2-ply.
   3. With chamfered edges.
   4. Lettering:
      a. Block style engraved characters of adequate size to be read easily from a distance of 6 feet.
      b. Minimum letter height: 1/8 inch.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and cable markers:
   1. Lettering:
      a. Machine printed black characters on white tubing.
      b. Minimum letter height: 10-point type or larger.

D. Conduit and raceway markers:
   1. Non-metallic:
      a. UV resistant holder and letters.
      b. Black letters on yellow background.
      c. Minimum letter height: 1/4 inch.
      d. Adhesive labels are not acceptable.

## PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 PREPARATION (NOT USED)

## 3.03 INSTALLATION

A. Nameplates:
   1. Attach to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. Provide for each disconnecting means with the following:
      a. Equipment served, voltage, and fuse size as required.
      b. Identification of the circuit source that supplies the disconnecting means.
   3. On NEMA Type 4X enclosures, use epoxy-based cement to attach nameplates.
   4. Aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

B. Conductor and cable markers:
   1. Apply before termination.
   2. Heat-shrinkable tubing:
      a. Shrunk using a heat gun that produces low temperature heated air.
      b. Tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

C. Conduit markers:
   1. Furnish and install markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Markings shall match the conduit schedule.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. The middle of conduits that are 10 feet or less in length.
      c. Where the conduit penetrates a wall, structure, manhole, or handhole.
         1) Marker shall be non-metallic with stainless steel hardware.
      d. Where the conduit emerges from the ground, slab, etc.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach non-metallic conduit markers with nylon cable ties:
      a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.

D. Signs and labeling:
   1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
      a. Fasten warning signs with round head stainless steel screws or bolts.

b. Locate and mount in a manner to be clearly legible to operations personnel.

2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc., where the voltage exceeds 600 volts.
3. Furnish and install warning signs on equipment that has more than one source of power.
   a. Warning signs to identify every panel and circuit number of the disconnecting means of external power sources.
4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
   a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

## 3.04 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers, or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

END OF SECTION

**SECTION 16123**

**600-VOLT OR LESS WIRES AND CABLES**

**TABLE OF CONTENTS**

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. 600-volt class or less wire and cable.

### 1.02 REFERENCES

A. Abbreviations:
   1. AWG: American wire gauge.
   2. BCCS: Bare copper-covered steel.
   3. CPE: Chlorinated polyethylene.
   4. FHDPE: Foam high-density polyethylene.
   5. FPE: Foam polyethylene.
   6. OD: Outside diameter.
   7. PVC: Polyvinyl chloride.
   8. XHHW: Cross-linked high heat water resistant insulated wire.

B. Standards:
   1. ASTM International (ASTM):
      a. B3 - Standard Specification for Soft or Annealed Copper Wire.
      b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. CSA International (CSA).
   3. Insulated Cable Engineers Association (ICEA):
      a. S-90-661 - Individually Unshielded Twisted Pair Indoor Cables for Use in Communication Wiring Systems.
   4. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
      a. NEMA WC 66/ICEA S-116-732 - Standard for Category 6 and 6A, 100 Ohm, Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in LAN Communication Wiring Systems.
      b. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
   5. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
      b. 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
   6. Telecommunications Industry Association (TIA):
      a. 568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
      b. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.
   7. Underwriters Laboratories Inc. (UL):
      a. 44 - Standard for Thermoset-Insulated Wires and Cables.
      b. 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

### 1.03 DELEGATED DESIGN (NOT USED)

## 1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Manufacturer of wire and cable.
   2. Insulation:
      a. Type.
      b. Voltage class.
   3. AWG size.
   4. Conductor material.
   5. Pulling compounds.

C. Test reports:
   1. Submit test reports for meg-ohm tests.

D. Cable lengths:
   1. Submit installed cable lengths using a conduit measuring tape for 3-phase circuits.

## 1.05 QUALITY ASSURANCE

A. Wires and cables shall be UL listed and labeled.

## 1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

## 1.07 PROJECT OR SITE CONDITIONS

A. General Site and Project conditions:
   1. As specified in Section 01850 - Design Criteria.

## 1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

# PART 2 PRODUCTS

## 2.01 GENERAL

A. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for 240/120-volt and 208/120-volt systems:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Single phase system: Black for 1 hot leg, red for the other.
      e. Neutral: White.
      f. High phase or wild leg: Orange.

g. Equipment ground: Green.

3. The following color code shall be followed for 480/277-volt systems:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral: Gray.
   e. Equipment ground: Green.
4. The following color code shall be followed for 120 VAC control wiring:
   a. Power: Red.
   b. Neutral: White.
5. The following color code shall be followed for general purpose DC control circuits:
   a. Grounded conductors: White with blue stripe.
   b. Ungrounded conductors: Blue.
6. Wire colors shall be implemented in the following methods:
   a. Use integral color insulation for #2 AWG and smaller wire.
   b. Wrap colored tape around cable larger than #2 AWG.
      1) Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
         a) Colored tape shall be wrapped to overlap half of the width of the tape.

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Furnish and install the complete wire and cable system.

## 2.03 MANUFACTURERS

A. One of the following, or equal:
   1. 600-volt class wire and cable:
      a. Okonite Co.
      b. Prysmian General Cable.
      c. Service Wire.
      d. Southwire Co.
   2. Instrumentation class wire and cable:
      a. Alpha Wire Co.
      b. Belden CDT.
      c. Okonite Co.
      d. Prysmian General Cable.
      e. Rockbestos Surprenant Cable Corp.
   3. Network cables:
      a. Belden.
      b. CommScope.
      c. General Cable.

## 2.04 MATERIALS

A. Conductors:
   1. Copper in accordance with ASTM B3.

## 2.05 MANUFACTURED UNITS

A. General:
   1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
   2. Permanently mark each wire and cable with the following at 24-inch intervals:
      a. AWG size.
      b. Voltage rating.
      c. Insulation type.
      d. UL symbol.
      e. Month and year of manufacture.
      f. Manufacturer's name.

B. 600-volt class wire and cable:
   1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
      a. When not indicated on the Drawings, size wire as follows:
         1) In accordance with the NEC:
            a) Use 75-degree Celsius ampacity ratings.
            b) Ampacity rating after derating factors, equal to or greater than rating of the overcurrent device.
         2) Provide #12 AWG minimum for power conductors.
         3) Provide #14 AWG minimum for control conductors.
   2. Provide Class B stranding in accordance with ASTM B8:
      a. Provide Class C stranding where extra flexibility is required.
   3. Insulation:
      a. XHHW-2.
      b. 90-degree Celsius rating.

C. Instrumentation class cable:
   1. Type TC.
   2. Suitable for use in wet locations.
   3. Voltage rating: 600 volts.
   4. Temperature rating:
      a. 90-degree Celsius rating in dry locations.
      b. 75-degree Celsius rating in wet locations.
   5. Conductors:
      a. Insulation:
         1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
      b. #16 AWG stranded and tinned.
      c. Color code: ICEA Method 1:
         1) Pair: Black and white.
         2) Triad: Black, white and red.
         3) Multiple pairs or triads:
            a) Color-coded and numbered.
   6. Drain wire:
      a. #18 AWG.
      b. Stranded, tinned.
   7. Jacket:
      a. Flame retardant, moisture and sunlight resistant PVC.

b. Ripcord laid longitudinally under jacket to facilitate removal.

8. Shielding:
   a. Individual pair/triad:
      1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
   b. Shielding to be in contact with the drain wire.

D. Network cables:
   1. Copper Ethernet cable:
      a. Provide copper Ethernet cable types as indicated on the Drawings and Specifications.
      b. General requirements:
         1) Cables shall meet the standards set by TIA-568.2-D and verified by third-party testing laboratory.
         2) Conductors:
            a) 4 balanced twisted pairs.
               (1) #22 to #24 AWG thermoplastic insulated solid copper conducts enclosed by a thermoplastic jacket. Copper clad aluminum is not allowed.
         3) Insulation:
            a) Non-Plenum: Polyolefin.
            b) Plenum: Fluoropolymer.
         4) Color coded per T568B.
         5) Outer jacket with ripcord.
         6) Shielding:
            a) Provide F/UTP cables with drain wire for cables inside any equipment or enclosure with 480 VAC and above, outdoor installations, and where indicated on the Drawings.
         7) Voltage rating:
            a) At a minimum provide 300 VAC rated jacket.
            b) 600 VAC rated jacket when cables are inside equipment or enclosures that contain 480 VAC power.
         8) Approvals and listings:
            a) Meets NEC requirements for each application.
            b) Riser applications: Type CMR.
            c) Plenum applications: Type CMP.
            d) Limited-use applications: Type CMX.
         9) Certification:
            a) Provide Category 5e cables with ICEA S-90-661 certification.
            b) Provide Category 6 cables with NEMA WC 66/ICEA S-116-732 certification.
            c) Provide Category 6A cables with NEMA WC 66/ICEA S-116-732 certification.

## 2.06 EQUIPMENT (NOT USED)

## 2.07 COMPONENTS (NOT USED)

## 2.08 ACCESSORIES

A. Wire ties:
   1. One of the following, or equal:
      a. Panduit, cable ties.
      b. T&B, “Ty-Rap” cable ties.

B. Wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

## 2.09 FABRICATION (NOT USED)

## 2.10 FINISHES (NOT USED)

## 2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall be in accordance with the applicable requirements of NEMA WC 70/ICEA S-95-658-1999.

B. Test type XHHW-2 in accordance with the requirements of UL 44.

# PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 PREPARATION (NOT USED)

## 3.03 INSTALLATION

A. Install conductors only after the conduit installation is complete, and enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
   1. Install wires only in approved raceways.
   2. Do not install wire:
      a. In incomplete conduit runs.
      b. Until after the concrete work and plastering is completed.

B. Cable pulling:
   1. Prevent mechanical damage to conductors during installation.
   2. For cables #1 AWG and smaller, install cables by hand.
   3. Add a junction box, conduit fitting, or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of the manufacturer’s recommendation for the specified cable size.

C. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems

D. Install and terminate wire in accordance with the manufacturer’s recommendations.

E. Terminate stranded conductors on equipment box lugs such that conductor strands are confined within the lug:
   1. Use ring type lugs if box lugs are not available on the equipment.

F. Apply wire markers to wires at each end after being installed in the conduit and before meg-ohm testing and termination.

G. Instrumentation class cable:
   1. Install instrumentation class cables in separate raceway systems from power cables:
      a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
      b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
   2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
   3. Shield grounding requirements as specified in Section 16060 - Grounding and Bonding.

H. Copper Ethernet cables:
   1. In accordance with TIA-568.2-D.
   2. Pathways:
      a. For initial installation, the maximum fill capacity for pathways (i.e., conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
      b. Conduit should be run in the most direct route possible with no more than two 90-degree bends between pull boxes and serve no more than 3 outlet boxes.
   3. Cable bend radius:
      a. Proper cable bend radius control must be maintained throughout the pathways. Bend radius needs to be at a minimum 10 times the cable diameter.
   4. Cable pulling:
      a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
      b. Maximum pulling tension is not to exceed the manufacturer's recommendations. Cable installation should not in any way deform the cable jacket.
      c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   5. Cable management:
      a. Organize and manage cables for quick and easy moves, adds and changes.
   6. Cable termination:
      a. Install equipment outlet connector hardware (e.g., RJ45, M12, etc.), and connect to field equipment outlet (e.g., instrument, VFD, actuator, etc.).
      b. Use shielded connectors as required by the installation.
      c. Coordinate cable termination at copper patch panels with ICSC and General Contractor.
   7. Testing:
      a. Copper Ethernet cable.
      b. Section 16950 - Field Electrical Acceptance Tests.

8. Separation from EMI sources:
    a. In accordance with TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
    b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
        1) Electrical equipment rating less than 2 kVA: A minimum of 5 inches.
        2) Electrical equipment rating between 2 and 5 kVA: A minimum of 12 inches.
        3) Electrical equipment rating more than 5 kVA: A minimum of 24 inches.
    c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
        1) Electrical equipment rating less than 2 kVA: A minimum of 2-1/2 inches.
        2) Electrical equipment rating between 2 and 5 kVA: A minimum of 6 inches.
        3) Electrical equipment rating more than 5 kVA: A minimum of 12 inches.
    d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
        1) Electrical equipment rating less than 2 kVA: No requirement.
        2) Electrical equipment rating between 2 and 5 kVA: A minimum of 3 inches.
        3) Electrical equipment rating more than 5 kVA: A minimum of 6 inches.
    e. Separation between communications cables and electrical motors and transformers, 5 kVA or HP and larger: A minimum of 48 inches.

I. Wiring allowances:
    1. Equipment locations may vary slightly from the Drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
    2. Locations for pull boxes, manholes, and duct banks may vary slightly from the Drawings. Include an allowance for necessary conductors and related materials to provide conductors to pull boxes, manholes and duct banks within 20-linear feet of locations indicated on the Drawings.

## 3.04 FIELD QUALITY CONTROL

A. Field electrical acceptance testing:
    1. Test wires and cables per industry standards as referenced by section 1.02.B above.

END OF SECTION

# SECTION 16130

# CONDUITS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Metallic conduits.
   2. Conduit bodies.
   3. Conduit fittings and accessories.
   4. Conduit installation.

### 1.02 REFERENCES

A. Abbreviations:
   1. GRC: Galvanized rigid steel conduit.
   2. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
   3. SLT: Sealtight-liquidtight flexible conduit.

B. Standards:
   1. American National Standards Institute (ANSI):
      a. C80.1 - Electrical Rigid Steel Conduit.
   2. National Electrical Manufacturers Association (NEMA):
   3. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   4. Underwriters Laboratories (UL), Inc.:
      a. 1 - Flexible Metal Conduit.
      b. 6 - Electrical Rigid Metal Conduit - Steel.

### 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. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, shapes C, E, LB, T, X, etc.
   2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.

### 1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures and Section 16070 - Hangers and Supports.

### 1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer's recommended special tools to be used for installation, if required.
   3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Shop Drawings:
   1. Detail the intended routing of each conduit, conduit material and include supporting methods.
   2. Number conduits in accordance with the Contract Documents.
      a. Provide conduit labels as specified in Section 16075 - Identification for Electrical Systems.

D. Delegated Design Submittals:
   1. As specified in Section 16070 - Hangers and Supports.

E. Record documents:
   1. Incorporate changes in conduit routing on electrical plan drawings.
   2. Dimension underground and concealed conduits from building lines.
   3. Furnish hard copy drawings.

## 1.06 QUALITY ASSURANCE

A. Conduits, conduit bodies, and fittings shall be UL listed and labeled.

## 1.07 DELIVERY, STORAGE, AND HANDLING

A. Do not expose non-metallic conduit to direct sunlight.

B. Do not store conduit in direct contact with the ground.

## 1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

## 1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

## PART 2 PRODUCTS

### 2.01 GENERAL (NOT USED)

### 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide conduits, conduit bodies, fittings, junction boxes, and necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

### 2.03 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Allied Tube and Conduit.
      b. Western Tube and Conduit.
      c. Wheatland Tube Co.

B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Allied.
      b. Calbond.
      c. NEC, Inc. BlackGuard.
      d. Ocal, Inc.
      e. Robroy Ind.

C. Conduit bodies:
   1. One of the following or equal:
      a. Appleton.
      b. Calbond.
      c. Carlon.
      d. Crouse-Hinds.
      e. Gibson,
      f. O-Z/Gedney.
      g. Ocal, Inc.
      h. Robroy Ind.

D. Joint compound:
   1. As recommended by the conduit manufacturer.

E. Galvanized rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

F. PVC-coated rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. NEC, Inc. BlackGuard.
      b. Ocal, Inc.
      c. Robroy Ind.

G. Conduit through wall and floor seals:
   1. The following or equal:
      a. O-Z/Gedney:
         1) Type “WSK.”
         2) Type “CSM.”

## 2.04 MATERIALS

A. Provide conduit bodies, hubs, and other accessories consistent with the conduit type specified in the table below.

| Conduit Type | Conduit Bodies and Covers | Fittings | Unions | Bushings and Hubs | Outlet Boxes |
|---|---|---|---|---|---|
| GRC | Malleable iron | Malleable iron | Malleable iron or zinc-plated steel | Malleable iron | Cast ferrous |
| PCS | PVC-coated malleable iron | PVC-coated malleable iron | PVC-coated steel | PVC-coated malleable iron | PVC-coated cast ferrous |

## 2.05 MANUFACTURED UNITS (NOT USED)

## 2.06 EQUIPMENT (NOT USED)

## 2.07 COMPONENTS

A. GRC:
   1. NPT standard conduit threads with a 3/4-inch taper per foot:
      a. Running conduit threads are not acceptable.
   2. Hot-dip galvanized inside and out:
      a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
      b. Electro-galvanizing is not acceptable.
   3. Manufactured in accordance with:
      a. UL 6.
      b. ANSI C80.1.

B. PCS:
   1. Steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, in accordance with to the requirements for Type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. Galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory-bonded PVC jacket:
      a. Exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch, except where part configuration or application of the piece dictates otherwise.

c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
d. PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
1) Confirm bond with certified test results.

4. Urethane coating shall be uniformly and consistently applied to the interior of conduits and fittings:
a. Nominal thickness of 0.002 inch.
b. Conduits having areas with thin or no coating are not acceptable.
c. Threads shall be coated with urethane.
5. PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
6. PCS conduit bodies and fittings:
a. Malleable iron.
b. Conduit body, before PVC coating, shall be new, unused material and shall be in accordance with appropriate UL standards.
c. PVC coating on the outside of conduit bodies shall be 0.040 inch thick and have a series of ribs to protect the coating from tool damage during installation.
d. 0.002-inch interior urethane coating.
e. Utilize PVC coating as an integral part of the gasket design.
f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
g. PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
1) Inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
2) Sleeve shall provide a vapor- and moisture resistant seal at every connection.
3) Fittings shall be Form 8 and supplied with plastic encapsulated stainless steel cover screws. Fittings shall be UL Type 4X. Fittings shall be from the same manufacturer as the conduit in order to maintain system continuity and warranty.

C. Conduit bodies:
1. In accordance with Form 8, Mark 9, or Mogul design:
a. Mogul design in accordance with NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
2. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

## 2.08 ACCESSORIES

A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
   1. Construction:
      a. Positive metallic conduit end stop.
      b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
      c. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
   1. Construction:
      a. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
      b. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions:
   1. Construction:
      a. Concrete tight, 3-piece construction for rigid metallic conduit.
      b. 2-piece construction for PVC-coated conduit.
      c. Rated for Class I, Division 1, Group D in hazardous areas.

E. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
   1. Construction:
      a. Insulated throat.
      b. PVC-coated when used in corrosive areas.
      c. Bonding locknut.
      d. Recessed neoprene O-ring to ensure watertight and dusttight connector.
      e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
      f. 1-1/2-inch through 6-inch malleable iron zinc plated.
   2. Usage:
      a. Conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

F. Through wall and floor seals:
   1. Materials:
      a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
      b. Grommet: Neoprene.
      c. Pressure rings: PVC-coated steel.
      d. Disc material: PVC-coated steel.

G. Expansion/deflection couplings:
   1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
   2. Shall allow movement of 3/4 inch from the normal in all directions.
   3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
   4. Constructed to maintain electrical continuity of the conduit system.
   5. Materials:
      a. End couplings: Bronze or galvanized ductile iron.
      b. Sleeve: Neoprene.

c. Bands: Stainless steel.
d. Bonding jumper: Tinned copper braid.

H. Expansion couplings:
1. Shall allow for expansion and contraction of conduit:
a. Permitting 8-inch movement, 4 inches in either direction.
2. Constructed to maintain electrical continuity of the conduit system.

I. Conduit markers:
1. As specified in Section 16075 - Identification for Electrical Systems.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Before installing any conduit or locating any device box:
1. Examine the complete set of Drawings and Specifications, and applicable Shop Drawings.

B. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

### 3.02 PREPARATION (NOT USED)

### 3.03 INSTALLATION

A. General:
1. Conduit routing:
a. Electrical drawings are diagrammatic in nature:
1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
b) Make changes in conduit routing due to the relocation of equipment.
c) Install conduits and equipment in such a manner as to avoid obstructions and to preserve headroom and keep openings and passageways clear.
3) Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
4) Electrical drawings do not indicate all required junction boxes and pull boxes:
a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
(1) To meet cable manufacturer’s pulling tension requirements.

(2) To limit total conduit bends between pull locations.

b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
   1) Engineer is the sole source in determining whether the change is constituted as a deviation.
   2) Perform any changes resulting in additional conduits, or extra work from such deviations.
   3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for conduit runs. Provide minimum clearances as follows:
   a. Clearance of 6 inches from surfaces 113 to 149 degrees Fahrenheit.
   b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
   c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
   d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
5. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
   b. Make changes in direction with long radius bends or with conduit bodies.
6. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
7. Route exposed conduits to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
   b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
8. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
9. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
10. Install conduits through wall and floor seals where indicated on the Drawings.
11. For new and existing underground and embedded conduits 1 inch and larger, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit.

12. Provide sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
13. Install complete conduit systems before conductors are installed.
14. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.

B. Equipment grounding conductors:
   1. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
      a. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
      b. Provide a separate grounding conductor in each individual raceway for parallel feeders.
   2. Conductors shall be the same type and insulation as the circuit conductors:
      a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
   3. Minimum size in accordance with the NEC.

C. Conduit usage:
   1. Exposed conduits:
      a. Rigid conduit:
         1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
         2) Minimum size: 3/4 inch.
      b. Flexible conduit:
         1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
            a) Use Type SLT with rigid metallic conduit.
         2) Minimum size: 3/4 inch:
            a) 1/2 when required for connection to instruments.
         3) Maximum length:
            a) Fixed equipment:

| Conduit Trade Size | Flexible Conduit Length (inch) |
|---|---|
| 3/4 | 18 |
| 1 | 18 |
| 1-1/4 | 18 |
| 1-1/2 | 18 |
| 2 | 36 |
| 2-1/2 | 36 |
| 3 | 36 |
| 3-1/2 | 38 |
| 4 | 40 |

b) Removable instruments or hinged equipment:
(1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. GRC:
a. Conduit shall be cut square and reamed before threading.

D. Conduit joints and bends:
1. General:
a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
b. Keep bends and offsets in conduit runs to an absolute minimum.
c. Bends shall be symmetrical.
d. The following conduit systems shall use large-radius sweep elbows:
1) Underground conduits.
2) Conduits containing shielded cables.
e. Provide factory-made elbows for large-radius bends for conduits 1-1/4-inch trade size or larger.
f. Make field bends with a radius of not less than the requirements found in the NEC:
1) Minimum bending radius of the cable must be less than the radius of the conduit bend.
2) Make field bends with power bending equipment or manual benders specifically intended for the purpose:
a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
b) For the serving utilities, make bends to meet their requirements.
3) For PCS conduit, field bends are permitted on conduits 1 inch and smaller. Manufactured elbows shall be used on conduits larger than 1 inch.
g. Replace deformed, flattened, or kinked conduit.
2. Threaded conduit:
a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
b. Thoroughly ream conduit after threads have been cut to remove burrs.
c. Use bushings or conduit fittings at conduit terminations.
d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing Galvabar™, or CRC Zinc It.
e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
1) Apply to the male threads and tighten joints securely.
2) Clean excess sealant from exposed threads after assembly.
f. Securely tighten threaded connections.

g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that exposed surfaces have a galvanized protective coating.

E. Hangers and supports:
   1. General:
      a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
         1) As specified in Section 16070 - Hangers and Supports.
         2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
      b. Support conduit at the intervals required by the NEC.
      c. Perforated strap and plumbers' tape are not acceptable for conduit supports.
   2. Conduit on concrete or masonry:
      a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
      b. Use preset inserts in concrete when possible.
      c. Use pipe spacers (clamp backs) in wet locations.
   3. Suspended conduit:
      a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
      b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2 feet long, provide rigid sway bracing.
   4. Supports at structural steel members:
      a. Use beam clamps.
      b. Drilling or welding may be used only as specified or with approval of the Engineer.

F. Expansion or expansion/deflection fittings:
   1. General:
      a. Align expansion coupling with the conduit run to prevent binding.
      b. Follow manufacturer's instructions to set the piston opening.
      c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
      d. Furnish fittings of the same material as the conduit system.
   2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
      a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

G. Miscellaneous:
   1. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
      a. Running threads and threadless couplings are not allowed.
   2. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
   3. Provide conduit housekeeping curb around embedded or below-grade conduits exiting or entering the slab.

END OF SECTION

# SECTION 16134

# BOXES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

### 1.02 REFERENCES

A. Joint Industry Conference (JIC).

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

D. Underwriters Laboratories, Inc. (UL):
   1. 514A - Metallic Outlet Boxes.

### 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. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

### 1.04 DELEGATED DESIGN (NOT USED)

### 1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Manufacturer.
   2. Materials.
   3. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
      d. Weight.
      e. NEMA rating.
   4. Conduit entry locations.

5. Catalog cutsheets.
6. Installation instructions.

C. Shop Drawings:
1. Include identification and sizes of pullboxes.

## 1.06 QUALITY ASSURANCE

A. Regulatory requirements:
1. Outlet boxes shall comply with applicable standards of:
a. JIC.
b. NEC.
c. NEMA.
d. UL.

## 1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

## 1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

## 1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

# PART 2 PRODUCTS

## 2.01 GENERAL (NOT USED)

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide outlet boxes for junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the Drawings and as needed to complete the raceway installation.

C. Size pullboxes in accordance with NEC requirements.

D. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.

E. For boxes not indicated:
1. Provide junction boxes and pull boxes as specified in Section 16050 - Common Work Results for Electrical.

## 2.03 MANUFACTURERS

A. One of the following or equal:
   1. Plastic coated boxes:
      a. OCAL.
      b. Rob Roy.
   2. Stainless steel enclosures:
      a. Hoffman.
      b. Rittal.
      c. Stahlin.

## 2.04 MATERIALS (NOT USED)

## 2.05 MANUFACTURED UNITS

A. Plastic coated cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
      f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
      g. With pressure sealing sleeve to protect the connection with conduit.

B. Formed steel enclosures:
   1. Stainless steel:
      a. NEMA Type 4X.
      b. Fabricated from 14-gauge Type 316 stainless steel.
      c. Seams continuously welded.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.
      i. Finish:
         1) Brushed.
      j. Stainless steel external mounting brackets when surface mounted.

## 2.06 EQUIPMENT (NOT USED)

## 2.07 COMPONENTS (NOT USED)

## 2.08 ACCESSORIES

A. Fasteners:
   1. Electroplated or stainless steel in boxes with wiring devices.
   2. Screws, nuts, bolts, and other threaded fasteners:
      a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

# PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 PREPARATION (NOT USED)

## 3.03 INSTALLATION

A. General:
   1. Provide outlet box materials to match the exposed conduit system as specified in Section 16130 - Conduits.
   2. Support wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
      a. Use machined spacers to maintain air space; built-up washers are not acceptable.
      b. Use stainless steel or nylon materials for spacers.
   3. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

B. Pullboxes and junction boxes:
   1. Provide junction box materials and NEMA ratings as specified in Section 16050 - Common Work Results for Electrical.
   2. Install pullboxes such that access to them is not restricted.

END OF SECTION

## SECTION 16140

## WIRING DEVICES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Switches.
   2. Receptacles.
   3. Device cover wall plates.

### 1.02 REFERENCES

A. Federal Specifications (FS):
   1. W-C-596 - Connector, Electrical, Power, General Specification for.
   2. W-S-896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

D. Telecommunications Industry Association (TIA):
   1. T568A - Eight-position jack pin/pair assignment.
   2. T568B - Optional eight-position jack pin/pair assignment.

E. Underwriters Laboratories, Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   3. 943 - Ground-Fault Circuit-Interrupters.

### 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. GFCI: Ground fault circuit interrupter.

### 1.04 DELEGATED DESIGN (NOT USED)

### 1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.

C. Shop Drawings:
    1. Engraving schedule:
        a. Furnish complete engraving schedule for engraved nameplates.

## 1.06 QUALITY ASSURANCE

A. Wiring devices shall be UL listed and labeled.

## 1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

## 1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

## 1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

# PART 2 PRODUCTS

## 2.01 GENERAL (NOT USED)

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Switches, receptacles, and device cover wall plates as indicated on the Drawings, wired and operable to form a complete system.

## 2.03 MANUFACTURERS

A. Switches:
    1. One of the following or equal:
        a. Cooper Wiring Devices.
        b. Hubbell.
        c. Leviton.

B. Receptacles:
    1. General purpose:
        a. One of the following or equal:
            1) Cooper Wiring Devices.
            2) Hubbell.
            3) Leviton.

C. Device cover wall plates:
    1. General location:
        a. One of the following or equal:
            1) Cooper Wiring Devices.
            2) Legrand.

2. Wet or corrosive areas:
    a. One of the following or equal:
        1) ABB.
        2) Cooper Wiring Devices.
        3) Hubbell.
        4) Pass and Seymour.
3. In-use covers:
    a. One of the following or equal:
        1) ABB.
        2) Cooper Wiring Devices.
        3) Pass and Seymour.
        4) TayMac.

## 2.04 MATERIALS (NOT USED)

## 2.05 MANUFACTURED UNITS

A. Switches:
    1. General:
        a. 120 to 277 VAC.
        b. 20 amp.
        c. Listed in accordance with UL 20.
        d. Designed and constructed in accordance with FS W-S-896/2.
        e. Back and side wired unless otherwise indicated.
        f. Integral grounding terminal.
        g. Totally enclosed:
            1) Color-coded body with color corresponding to amp rating.
        h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
        i. Color:
            1) Ivory in finished areas.
            2) Brown in all other areas.
    2. General purpose switches:
        a. Toggle type.

B. Receptacles:
    1. General purpose receptacles:
        a. Single or duplex as indicated on the Drawings.
        b. 125 VAC.
        c. 20 amp or as indicated on the Drawings.
        d. NEMA Type 5-20R configuration for 20 amp receptacles.
        e. Other NEMA configurations as indicated on the Drawings.
        f. Listed in accordance with UL 498.
        g. Designed and constructed in accordance with FS W-C-596.
        h. Back and side wired.
        i. 1-piece, rivet-less mounting strap.
        j. Color:
            1) Ivory in finished areas.
            2) Brown in all other areas.
            3) Orange when powered by a UPS.

C. Device cover wall plates:
    1. General location:
        a. Type 302 or 304 stainless steel.
        b. Brushed satin finish.
        c. Minimum thickness: 0.032 inches.
        d. Rectangular or square shape.
        e. Engraving:
            1) Engrave each switch device cover wall plate with the following:
                a) Area served.
                b) Panelboard and Circuit.
            2) Engrave each receptacle device cover wall plate with the following:
                a) Panelboard and Circuit.
            3) Treat engraving to improve visibility.
            4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
        f. Coordinate the number of gangs, number, and type of openings with the specific location.
    2. Corrosive areas:
        a. Neoprene.
        b. Gasketed.
        c. Weatherproof.

## PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 PREPARATION (NOT USED)

## 3.03 INSTALLATION

A. Mounting heights:
    1. Process and production areas:
        a. Switches and receptacles: 48 inches from finished floor to top of device cover wall plate.

B. Receptacles:
    1. Provide GFCI receptacles as indicated on the Drawings.
        a. Provide weather resistant GFCI receptacles in wet or damp areas.
    2. Mount receptacles vertically:
        a. Ground slot down.
    3. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.

C. Ensure device cover wall plates make a firm seal with wall for recessed mounted devices:
    1. Outside edges of device cover wall plates parallel with building lines.

END OF SECTION

# SECTION 16150

# LOW VOLTAGE WIRE CONNECTIONS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.
   3. Splices.
   4. Power distribution blocks.

### 1.02 REFERENCES

A. ASTM International (ASTM):
   1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

B. CSA International (CSA):
   1. C22.2 - No. 197-M1983 (R2208) - PVC Insulating Tape.

C. Underwriters Laboratories, Inc. (UL):
   1. 486A-B - Standard of Safety for Wire Connectors.
   2. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   3. 1953 - Outline of Investigation for Power Distribution Blocks.

### 1.03 DELEGATED DESIGN (NOT USED)

### 1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.
   2. Installation instructions.

### 1.05 QUALITY ASSURANCE

A. Materials shall be UL listed.

### 1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

### 1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

### 1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

# PART 2 PRODUCTS

## 2.01 GENERAL (NOT USED)

## 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide a complete system of wiring connectors, terminators, fittings, etc., for a complete wiring system suitable for the cables and conductors used.

## 2.03 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

## 2.04 MATERIALS (NOT USED)

## 2.05 MANUFACTURED UNITS (NOT USED)

## 2.06 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
      d. Electroplated-tin copper conductor.
      e. Manufacturers: The following or equal:
         1) ABB, Sta-Kon.
   2. For process equipment connections, work from the manufacturer's drawings.

B. Joints, splices, taps, connections, and terminations:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Copper pigtail adaptors.
         1) For use on select applications as approved by the Engineer.
         2) 600 volt, 90 degrees Celsius rated.
         3) UL 486A/B listed.
         4) Manufacturers: One of the following or equal:
            a) Burndy APY series.
            b) ILSCO CPM series.
      c. Use only plated copper alloy connectors or lugs:
         1) Aluminum connectors or lugs are not acceptable for copper conductors.

d. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
e. For wire #10 AWG and smaller, use compression splice caps, with insulating caps:
    1) Manufacturers: The following or equal:
        a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
f. For wire #8 AWG and larger, use heavy duty copper compression connectors:
    1) Manufacturers: One of the following or equal:
        a) ABB.
        b) Burndy.
g. Heat shrink tubing:
    1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
    2) Minimum shrink ratio: 4 to 1.
    3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
    4) Internally applied adhesive sealant.
    5) Cross-linked polyolefin:
        a) Manufacturers: One of the following or equal:
            (1) 3M, ITCSN.
            (2) ABB, Shrink-Kon.

2. Instrumentation class cable splices:
    a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
    b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
    c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
    d. Two-part mold body with tongue and groove seams and built-in spacer webbing.
    e. Manufacturers: The following or equal:
        1) 3M, Scotchcast 72-N.

C. Insulating tape:
1. General purpose insulating tape:
    a. Minimum 7 mil vinyl tape.
    b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
    c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
    d. Flame retardant, hot- and cold-weather resistant, UV resistant.
    e. For use as a primary insulation for wire cable splices up to 600 VAC.
    f. Meeting and complying with:
        1) ASTM D3005, Type I.
        2) UL 510.
        3) CSA C22.2.
    g. Manufacturers: The following or equal:
        1) 3M, Scotch Number Super 33+.
2. General purpose color-coding tape:
    a. Minimum 7 mil vinyl tape.
    b. Suitable for application on PVC and polyethylene jacketed cables.

c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
    1) Red.
    2) Yellow.
    3) Blue.
    4) Brown.
    5) Gray.
    6) White.
    7) Green.
    8) Orange.
    9) Violet.
e. For use as phase identification, marking, insulating, and harnessing.
f. Meeting and complying with:
    1) UL 510.
    2) CSA C22.2.
g. Manufacturers: The following or equal:
    1) 3M, Scotch Number 35.

D. Power distribution blocks:
1. UL 1953 listed.
2. Short circuit rating: Not less than the system maximum available fault current at the point of application.
3. Provide fuses or circuit breakers in enclosure as required to meet the fault current requirements.
4. Voltage rating: 600 VAC.
5. IP 20 finger safe enclosure.
6. Tin-plated aluminum or copper terminals suitable for copper conductors.
7. Manufacturers: One of the following or equal:
    a. Eaton CHDB series.
    b. Rockwell Automation 1492 PD series.
    c. Schneider Electric LB series.

## PART 3 EXECUTION

### 3.01 EXAMINATION (NOT USED)

### 3.02 PREPARATION (NOT USED)

### 3.03 INSTALLATION

A. Load connections:
1. Connect loads to the circuits as indicated. Color-code branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.

B. Zero to 600-volt systems:
1. Make connections with the proper tool and die as specified by the device manufacturer.
2. Use only tooling and dies manufactured by the device manufacturer.
3. Insulate connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.

4. Number power and control wires before termination.

C. Motor connections (600 volts and below):
   1. Terminations on motor leads, including leads that are connected to accommodate the motor current, and the wires entering the motor terminal box from the power source, shall have ring type compression lugs or mechanical torqued insulated lugs.
   2. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
      a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
      b. Shrink cap with low heat as recommended by the manufacturer.
   3. Wire markers shall be readable after boot installation.
   4. Manufacturers: One of the following or equal:
      a. ABB, Blackburn Insulated multi-taps connectors.
      b. NSI Industries, Polaris insul-tap connectors.
      c. Raychem, MCK.

END OF SECTION

# SECTION 16990

# CONDUIT SCHEDULE

## PART 1 GENERAL

### 1.01 SUMMARY

A. Conduit requirements:
   1. As defined in Section 16050 and Section 16130.

B. Cable requirements and definitions:
   1. As defined in Section 16050 and Section 16123.
   2. 2/CS#16: 2 conductor, 16 gauge, twisted shielded pair.
   3. CAT6: Category 6 Ethernet cable.

## PART 2 PRODUCTS

Not Used.

## PART 3 EXECUTION

### 3.01 CONDUIT SCHEDULE

A. Conduit Schedule is presented on the following pages.

# CONDUIT SCHEDULE AREA

**SNYDERVILLE BASIN WATER RECLAMATION DISTRICT**

**DEWATERING BUILDING EQUIPMENT PREPURCHASE**

**ENGINEER** [FILL]

**REVISION**

**DATE** 5/14/25

| CONDUIT | | | CONDUCTORS | | | GROUND | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | DWG | SIZE | # | SIZE | TYPE | # | SIZE | TYPE | DESCRIPTION | CONNECTING SEGMENTS |
| C-26-001 | 00E03 | 0.75" | 2 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: FIT-26119<br>TO: J-BOX<br>2 #12 >> FIT-26119 -24VDC POWER | |
| C-26-002 | 00E03 | 0.75" | 2 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: FIT-26115<br>TO: J-BOX<br>2 #12 >> FIT-26115 -24VDC POWER | |
| C-26-005 | 00E03 | 1" | 4<br>8 | #12<br>#14 | XHHW-2<br>XHHW-2 | 1 | #12 | XHHW-2 | FR: J-BOX<br>TO: J-BOX<br>2 #12 >> FIT-26119 -24VDC POWER<br>2 #12 >> FIT-26115 -24VDC POWER<br>4 #14 >> FLC-26110 FEED VALVE<br>4 #14 >> FLC-26110 RECIRC VALVE | C-4001<br>C-4002 |
| C-26-006 | 00E03 | 0.75" | 2 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: FIT-26139<br>TO: J-BOX<br>2 #12 >> FIT-26139 -24VDC POWER | |
| C-26-007 | 00E03 | 0.75" | 2 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: FIT-26135<br>TO: J-BOX<br>2 #12 >> FIT-26135 -24VDC POWER | |
| C-26-009 | 00E03 | 0.75" | 8 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: J-BOX<br>TO: VCP1-26120<br>2 #12 >> FIT-26119 -24VDC POWER<br>2 #12 >> FIT-26115 -24VDC POWER<br>2 #12 >> FIT-26139 -24VDC POWER<br>2 #12 >> FIT-26135 -24VDC POWER | C-4005<br>C-4005<br>C-4006<br>C-4007 |
| C-26-011 | 00E03 | 1" | 16 | #14 | XHHW-2 | 1 | #14 | XHHW-2 | FR: JB101<br>TO: JB102<br>16 #14 >> RPR-26120 CONTROL | |
| C-26-012 | 00E03 | 2" | 32 | #14 | XHHW-2 | 1 | #14 | XHHW-2 | FR: JB102<br>TO: VCP1-26120<br>16 #14 >> RPR-26120 CONTROL<br>16 #14 >> RPR-26140 CONTROL | C-4011 |
| C-26-021 | 00E03 | 1" | 12 | #14 | XHHW-2 | 1 | #14 | XHHW-2 | FR: VCP1-26120<br>TO: VCP2-26120<br>12 #14 >> VCP2-26120 VFD PNL STATUS/CTRL | |
| L-26-001 | 00E03 | 0.75" | 2 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: VCP1-26120<br>TO: VCP2-26120<br>2 #12 >> VCP2-26120 -120 VAC POWER | |
| L-26-002 | 00E03 | 0.75" | 2 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: AIR DRYER<br>TO: LP-S<br>2 #12 >> AIR DRYER 120 VAC POWER | |
| N-26-001 | 00E03 | 1" | 2 | | CAT6 | 1 | #14 | XHHW-2 | FR: VCP1-26120<br>TO: PLC-200<br>2 CAT6 >> NETWORK INTERFACE | |
| | | | | | | | 52 | | | |
| N-26-002 | 00E03 | 0.75" | 1 | | CAT6 | 1 | #14 | XHHW-2 | FR: VCP1-26120<br>TO: VCP2-26120<br>1 CAT6 >> NETWORK CONNECTION | |
| P-26-000 | 00E03 | 0.75" | 3 | #8 | XHHW-2 | 1 | #10 | XHHW-2 | FR: VCP2-26120<br>TO: MCC-S<br>3 #8 >> VCP2-26120 POWER | |
| P-26-001 | 00E03 | 0.75" | 3 | #10 | XHHW-2 | 1 | #10 | XHHW-2 | FR: FLC-26110<br>TO: VCP2-26120<br>3 #10 >> FLC-26110 | |
| P-26-002 | 00E03 | 0.75" | 3 | #10 | XHHW-2 | 1 | #10 | XHHW-2 | FR: FLC-26110<br>TO: VCP2-26120<br>3 #10 >> FLC-26130 | |
| P-26-005 | 00E03 | 0.75" | 3 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: ARC-26100<br>TO: DISCONNECT<br>3 #12 >> ARC-26100 | P-26-006 |
| P-26-006 | 00E03 | 0.75" | 3 | #12 | XHHW-2 | 1 | #12 | XHHW-2 | FR: DISCONNECT<br>TO: MCC-S<br>3 #12 >> ARC-26100 | P-26-005 |
| S-26-001 | 00E03 | 0.75" | 1 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: FIT-26119<br>TO: J-BOX<br>1 2/CS-#16 >> FIT-26119 | |

# CONDUIT SCHEDULE AREA

**SNYDERVILLE BASIN WATER RECLAMATION DISTRICT**

**DEWATERING BUILDING EQUIPMENT PREPURCHASE**

**ENGINEER** [FILL]

**REVISION**

**DATE** 5/14/25

| CONDUIT | | | CONDUCTORS | | | GROUND | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | DWG | SIZE | # | SIZE | TYPE | # | SIZE | TYPE | DESCRIPTION | CONNECTING SEGMENTS |
| S-26-002 | 00E03 | 0.75" | 1 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: FIT-26115 | |
| | | | | | | | | | TO: J-BOX | |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26115 | |
| S-26-003 | 00E03 | 0.75" | 1 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: PIT-26113 | |
| | | | | | | | | | TO: J-BOX | |
| | | | | | | | | | 1 2/CS-#16 >> PIT-26113 | |
| S-26-005 | 00E03 | 1" | 4 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: J-BOX | S-26-009 |
| | | | | | | | | | TO: J-BOX | |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26119 | S-26-6001 |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26115 | S-26-6002 |
| | | | | | | | | | 1 2/CS-#16 >> PIT-26113 | S-26-6003 |
| | | | | | | | | | 1 2/CS-#16 >> FCV-26115 PROPORTIONING VALVE | |
| S-26-006 | 00E03 | 0.75" | 1 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: FIT-26139 | S-26-009 |
| | | | | | | | | | TO: J-BOX | |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26139 | |
| S-26-007 | 00E03 | 0.75" | 1 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: FIT-26135 | S-26-009 |
| | | | | | | | | | TO: J-BOX | |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26135 | |
| S-26-008 | 00E03 | 0.75" | 1 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: PIT-26133 | S-26-009 |
| | | | | | | | | | TO: J-BOX | |
| | | | | | | | | | 1 2/CS-#16 >> PIT-26133 | |
| S-26-009 | 00E03 | 1.5" | 8 | 2/CS-#16 | | 1 | #14 | XHHW-2 | FR: J-BOX | |
| | | | | | | | | | TO: VCP1-26120 | |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26119 | S-26-005 |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26115 | S-26-005 |
| | | | | | | | | | 1 2/CS-#16 >> PIT-26113 | S-26-005 |
| | | | | | | | | | 1 2/CS-#16 >> FCV-26115 PROPORTIONING VALVE | S-26-005 |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26139 | S-26-006 |
| | | | | | | | | | 1 2/CS-#16 >> FIT-26135 | S-26-007 |
| | | | | | | | | | 1 2/CS-#16 >> PIT-26133 | S-26-008 |
| | | | | | | | | | 1 2/CS-#16 >> FCV-26135 PROPORTIONING VALVE | |
| S-26-011 | 00E03 | 1" | 1 | | CAT6 | 1 | #14 | XHHW-2 | FR: JB101 | S-26-012 |
| | | | 2 | 2/CS-#16 | | | | | TO: JB102 | |
| | | | | | | | | | 2 2/CS-#16 >> RPR-26120 SIGNAL | |
| | | | | | | | | | 1 CAT6 >> NETWORK CABLE - JB101 | |
| S-26-012 | 00E03 | 1.5" | 2 | | CAT6 | 1 | #14 | XHHW-2 | FR: JB101 | |
| | | | 4 | 2/CS-#16 | | | | | TO: VCP1-26120 | |
| | | | | | | | | | 2 2/CS-#16 >> RPR-26120 SIGNAL | S-26-011 |
| | | | | | | | | | 1 CAT6 >> NETWORK CABLE - JB101 | S-26-011 |
| | | | | | | | | | 2 2/CS-#16 >> RPR-26140 SIGNAL | |
| | | | | | | | | | 1 CAT6 >> NETWORK CABLE - JB102 | |

END OF CONDUIT SCHEDULE

END OF SECTION

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## SECTION 17050

## COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

# PART 1 GENERAL

## 1.01 SUMMARY

A. Section includes:
   1. Process control and instrumentation systems requirements for common components including installation, including, but not limited to, the following:
      a. Hardware.
      b. Software.
      c. Programming.
      d. Testing.
      e. Commissioning.
   2. Requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in Technical Sections, including packaged mechanical systems, local control panels (LCPs), vendor control panels (VCPs), etc.
   3. As specified in this Section, some PLC programming and SCADA/HMI software configuration will be provided by the Owner, hereinafter referred to as the programmer.

B. Contract Drawings:
   1. Schematic diagrams:
      a. Use schematic diagrams in conjunction with the descriptive operating sequence in the Technical Sections to furnish a coordinated and fully functional control system.
      b. Schematic diagrams show control function only.
         1) Incorporate other necessary functions for proper operation and protection of the system.
      c. Controls are indicated on the Drawings as de-energized.
      d. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      e. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated on the Drawings.

## 1.02 REFERENCES

A. Abbreviations:
   1. ACB: Automatic current balance.
   2. ATS: Automatic transfer switch.
   3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that

includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.

4. DPDT: Double-pole, double-throw.
5. ECP: Electronic circuit protector.
6. ES: Ethernet switch.
7. FAT: Factory acceptance test, also known as Source Test.
8. HART: Highway addressable remote transducer.
9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically, information is displayed in a graphical format.
10. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped, and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
11. I/O: Input/output.
12. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
13. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
14. IP: Internet protocol or ingress protection.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
16. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
17. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
18. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the LOR. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
19. NP: Network panel. An enclosure that contains network equipment.
20. P&ID: Process and instrumentation diagram.
21. PC: Personal computer.
22. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.

23. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
24. PCS: Process control system: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs, and all data management systems accessible to staff.
25. PLC: Programmable logic controller.
26. PS: Power supply.
27. RIO: Remote I/O device for the PLC consisting of remote I/O racks or remote I/O blocks.
28. RTU: Remote telemetry unit: A controller typically consisting of a PLC and a means for remote communications. The remote communications devices typically are radios, modems, etc.
29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
30. SELV: Safety extra-low voltage.
31. SFP: Small form-factor pluggable.
32. SPDT: Single-pole, double-throw.
33. SPST: Single-pole, single-throw.
34. UPS: Uninterruptible power supply.
35. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
36. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

B. Standards:
   1. American Petroleum Institute (API):
      a. RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
      b. RP 551 - Process Measurement Instrumentation.
   2. International Organization for Standardization (ISO):
      a. 9001 - Quality Management Systems - Requirements.
   3. International Society of Automation (ISA):
      a. 5.1 - Instrumentation Symbols and Identification.
      b. 5.4 - Instrument Loop Diagrams.
      c. 20 - Instrument Forms Plus Pro-Combo-Enterprise Version (Microsoft SQL Server Express Database Software based).
   4. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   5. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   6. National Institute of Standards and Technology (NIST).
   7. Underwriters Laboratories, Inc. (UL):
      a. 508 - Standard of Safety for Industrial Control Equipment.
      b. 508A - Standard of Safety for Industrial Control Panels.

## 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. Two-wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
      a. Fieldbus communications signal or both.
   2. Four-wire transmitter: A transmitter that utilizes a power loop separate from the signal loop. With the power loop isolated from the signal loop, the source of instrument power can be 24 VAC/VDC or 120/240 VAC. The transmitter provides a 4 to 20 mA 24 VDC signal.
   3. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
   4. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
   5. Instrument: A measurement device that includes a sensor for taking the measurement and one or both of the following:
      a. A local display.
      b. A device for communicating the measurement to a remote location such as a PLC or DCS.
   6. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
   7. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
   8. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
   9. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.
   10. Programmer: Responsible for PLC programming and SCADA/HMI software configuration.
   11. RS-485: Also known as TIA-485 or EIA-485. Is a standard defining the electrical characteristics of drivers and receivers for use in serial communications system. Electrical signaling is balanced, and multipoint systems are supported, can be used with data rates up to 10 Mbit/s or at lower speeds distances up to 1,200 meters (4,000 feet).
   12. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.

## 1.04 DELEGATED DESIGN

A. Requirements for Delegated Design are specified in the Technical Sections.

## 1.05 SUBMITTALS

A. General:
   1. Adhere to the wiring numbering scheme as specified in Section 16075 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on equipment drawings.
   2. Some items of Work are represented schematically and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
      a. Employ the nomenclature and numbers specified in this Section and indicated on the Drawings exclusively throughout Shop Drawings, datasheets, and similar Submittals.
      b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, Supplier's, or Subcontractor's standard methods with those specified in this Section and indicated on the Drawings.

B. Specific Submittal requirements:
   1. Control panel drawings:
      a. General requirements:
         1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for items provided.
         2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
         3) Nameplates and wire labeling:
            a) Nameplate legend, including text, letter size, materials, and colors.
            b) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
         4) Structural requirements:
            a) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project Site seismic criteria.
            b) Weight.
         5) Clearly show modifications to existing circuits:
            a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
      b. Required for materials and equipment listed in this and other Technical Sections.
      c. Front, side, rear, internal, external elevations, and top and bottom views, showing all dimensions and all to scale.
         1) Locations of conduit entrances and access plates.
         2) Component layout and identification.
         3) Complete and detailed bills of materials:
            a) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
            b) Include all items within an enclosure.
         4) Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.
         5) Complete grounding requirements for each system component, including any requirements for PLCs, process LANs, and control system equipment.

6) PLC rack and card layout:
    a) Provide a count of current I/O allocation.
    b) Future I/O allocation.
    c) Quantity of spares provided.
7) NEMA rating.
8) Material and finish.

2. Schematics and wiring diagrams:
    a. General requirements:
        1) Submit panel wiring diagrams for every panel that contains wiring.
        2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
        3) Nameplates and wire labeling:
            a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
        4) Clearly show modifications to existing circuits:
            a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
    b. Include the following information:
        1) Name of panel.
        2) Wiring sizes and types.
        3) Terminal strip numbers.
        4) Terminal identification for device and field connections.
        5) Wire tags and labels.
        6) Functional name and manufacturer's designation for items to which wiring are connected.
        7) Set points for relays and control or alarm contact settings.
    c. Incorporate equipment manufacturer's Shop Drawing information into the schematic diagrams in order to document the entire control system.
3. Product data:
    a. Provide a technical brochure or bulletin (cutsheet) for each instrument or equipment on the Project, labeled with equipment and instrument tags as depicted on the P&IDs.
        1) Submit with the corresponding datasheets.
        2) Organization: Index product data in the Submittal by systems or loops.
    b. Engineering data:
        1) Test data and performance curves, when applicable.
    c. Manufacturer's technical reference manuals.
4. Quality Control Submittals:
    a. As specified in Section 01756 - Commissioning.
    b. Manufacturer representative qualifications.
    c. Manufacturer certificates.
    d. Test Plans.
    e. Test Reports.
5. Owner Training Submittals.
    a. As specified in Section 01756 - Commissioning.
6. Operation and maintenance manuals:
    a. As specified in Section 01782 - Operation and Maintenance Manuals.
    b. Organize the operation and maintenance manuals for each process in the following manner:
        1) Section A - Schematics and Wiring Diagrams.

2) Section B - Product Data.
3) Section C - Test Results.
4) Section D - Operational Manual.
5) Section E - Spare Parts List.

## 1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. Provide equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

## 1.07 DELIVERY, STORAGE, AND HANDLING

A. Upon receipt of instruments in the field:
   1. Outside of the package: Prominently display tag number identification.
   2. On each instrument: Provide a nameplate as specified in this Section.

## 1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

B. Area classifications:
   1. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.

## 1.09 ADMINISTRATIVE REQUIREMENTS

A. Conduct the following meetings as specified in Section 01312 - Project Meetings.

B. Control logic meetings:
   1. Preliminary meeting:
      a. Contractor leads the meeting.
      b. Timing:
         1) Before configuration work is begun on any PLCs programmed by the Contractor (including those provided through Subcontractors and Suppliers).
      c. Attendees:
         1) Owner, Rotary Press Supplier, Engineer, and Programmer.
         2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
      d. Agenda:
         1) Meeting purpose:
            a) Discuss overall control logic.
         2) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
         3) Review contact information for each individual responsible for programming each said PLC and other programmable device.

4) Review schedule of Submittals that will contain HMI/LOI interface information.
5) Safety and security.
6) Action items.
7) Next meeting.

2. Vendor programming meetings:
   a. Contractor leads the meeting.
   b. Timing:
      1) Prior to start of programming work for VCPs or other vendor equipment such as MCCs.
   c. Attendees:
      1) Owner, Engineer, Rotary Press Supplier and Programmer.
      2) Individuals responsible for programming PLCs and other programmable devices supplied by the Contractor may attend by telephone conference call.
      3) Each equipment supplier who is providing equipment with a PLC and/or LOI.
   d. Agenda:
      1) Meeting purpose:
         a) Coordinate control logic requirements for specific equipment.
      2) Review minimum VCP programming requirements:
         a) PLC to PLC global data mapping.
         b) PLCs to HMI tags mapping.
         c) Communication methods.
      3) Review advanced VCP programming requirements, as applicable:
         a) Tag naming conventions.
         b) LOI screen colors and navigation.
         c) Interlock and permissive definitions.
         d) Alarms: Clearing, formats, colors, and status.
         e) Standard code blocks for common control functionality.
      4) Safety and security.
      5) Action items.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. Furnish meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of Submittal of the Shop Drawings unless otherwise specified to match existing equipment.

### 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Non-conditioned spaces:
   1. Provide additional temperature conditioning equipment to maintain equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines.

B. Outdoor installations:
   1. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
   2. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in the Sections for the equipment.

C. This facility includes classified areas:
   1. As specified in Section 16050 - Common Work Results for Electrical.
   2. Provide enclosures suitable for the area classification.
   3. Where suitable enclosures are not available, utilize other methods such as intrinsic safety barriers.

D. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity, or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts: Fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:
   1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
   3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
   4. Terminate the signal cable shield on a dedicated grounding terminal block.
   5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

F. Instrument air:
   1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to field instruments and instrument panels requiring air:
      a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
      b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
      c. Filter air to 5-micron maximum particle size.
      d. Provide low pressure switch to alarm on insufficient air supply.

G. Terminal blocks:
   1. Schematics do not reflect the actual conductor routing. Add intermediate terminal in enclosures and equipment as needed based on the actual conductor routing.

H. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4 to 20 mA 24 VDC, except as indicated.
      c. Electrically or optically isolate analog signals from other signals.
      d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      e. Maintain the total 4 to 20 mA loop impedance to 10 percent below the published value at the loop operating voltage.
      f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
   2. Pneumatic signals: 3 to 15 pounds per square inch gauge.
   3. Discrete input signals: As indicated in the controller hardware specification.
   4. Discrete output signals:
      a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
      b. Provide external terminal block mounted fuse with blown fuse indication for discrete outputs.
      c. Provide interposing relays for discrete outputs for voltage and/or current compatibilities.
      d. Provide interposing relays as required for functionality of the control circuit.
   5. Signal performance and design criteria:
      a. Stability:
         1) After controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
      b. Response:
         1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
      c. Agreement:
         1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
      d. Repeatability:
         1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
      e. Sensitivity:
         1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
      f. Performance:
         1) Instruments and control devices shall perform in accordance with the manufacturers' specifications.

## 2.03 ACCESSORIES (NOT USED)

## PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 PREPARATION (NOT USED)

## 3.03 INSTALLATION

A. PCIS configurations are diagrammatic:
   1. Locations of equipment are approximate unless dimensioned.
   2. Where Project conditions require, make reasonable changes in locations and arrangements.

B. Field instruments installation:
   1. As specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
      b. Provide sun shields for field electronic instruments, panels, and enclosures located outdoors. Sun shields shall include standoffs to allow air gap between shield and equipment.
      c. Orient LED, LCD, or other readout screens north to minimize sun glare and reduce potential of sun damage.
   3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
      a. Type of flexible conduit required for the area classification:
         1) As specified in Section 16050 - Common Work Results for Electrical.
      b. Maximum length of 18 inches.
   4. Connect field instruments with cable as specified in the electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
      a. Special cable applications shall be in accordance with the NEC.
   5. Verify the correctness of each installation:
      a. Polarity of electric power and signal connections.
   6. Ensure process connections are free of leaks.

C. Process sensing lines and air tubing:
   1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
   2. Provide supports for rigid tubing at intervals of not more than 3 feet.
   3. Slope horizontal runs of instrument tubing at a minimum of 1/16 inch per foot to allow for draining of any condensate.
   4. Bends:
      a. Make bends for parallel lines symmetrical.
      b. Make bends without deforming or thinning the walls of the tubing.
   5. Square-cut and clean ends of tubing before being inserted in the fittings.
   6. Provide bulkhead fittings at panels requiring pipe and/or tubing entries.

7. Use stainless steel tubing for piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

D. Cable and conductor termination:
1. Terminate cables and conductors on terminal blocks.
2. Terminal block enclosures:
    a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.

E. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
2. Individually fuse each 4 to 20 mA DC loop with a 1/2-amp fuse between power supplies and receiver surge protectors.
3. Provide voltage surge protection for 4-wire transmitters and analyzers:
    a. Protect both power source and signal loop.

## 3.04 RE-INSTALLATION

A. Existing instrumentation:
1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
2. Provide certification of this Work before reinstallation of each instrument.

## 3.05 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

## 3.06 FIELD QUALITY CONTROL

A. Functional Testing:
1. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
2. Assist with troubleshooting and correcting instrumentation and control issues.

## 3.07 ADJUSTING

A. Control valves:
1. Stroke control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

## 3.08 CLEANING

A. Vacuum clean control panels and enclosures before process start-up and again after final completion of the Project.

B. Clean panel surfaces.

C. Return to new condition any scratches and/or defects.

D. Wipe instrument faces and enclosures clean.

E. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label spare wiring lengths.
   2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

END OF SECTION

## SECTION 17710

## CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

## TABLE OF CONTENTS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of instrumentation enclosures, control panels and components provided under this Contract, including, but not limited to:
      a. Custom built instrumentation and control panels, including enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

### 1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
      b. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
      c. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
   2. International Electrotechnical Commission (IEC):
      a. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
      b. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
   3. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   4. Underwriters Laboratories Inc. (UL):
      a. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.
      b. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
      c. 508 - Standard for Industrial Control Equipment.
      d. 508A - Standard for Industrial Control Panel.
      e. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.

f. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
g. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
h. 1283 - Standard for Electromagnetic Interference Filters.
i. 1310 - Standard for Class 2 Power Units.
j. 1449 - Standard for Surge Protective Devices.

## 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. The term “panel” in this Section is interchangeable with the term “enclosure.”

## 1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

## 1.05 SUBMITTALS

A. Provide Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide a control panel hardware Submittal for each control panel/enclosure being provided on this Project, including, but not limited to:
   1. Product data:
      a. Enclosure construction details and NEMA type.
      b. Manufacturer’s literature and specification datasheets for each type of equipment to be installed within or on the panel or enclosure.
   2. Shop Drawings:
      a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
         1) Provide draft for review and approval by the Engineer. Engineer has the authority to substantially alter initial panel layouts.
      b. Complete nameplate engraving schedule.
      c. Structural details of fabricated panels.
   3. Calculations:
      a. Cooling calculations, including, but not limited to:
         1) Highest expected ambient temperature for the enclosure’s location.
         2) Internal heat load.
         3) Exposure to direct sunlight.
         4) Dimensions of the enclosure in inches.
         5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria:
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

## 1.06 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Assemble panels, enclosures, and rack systems along with internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
   1. Provide components and equipment with UL 508 listing.
   2. Control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the Contract Documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
      a. Non-listed, complex, and unique equipment may be evaluated and approved by a third-party testing agency, with prior approval by the Owner. Provide report documenting the testing standard, specification, method of testing, and that the equipment and materials meet appropriate designated standards or have been tested and found suitable for use in a specified manner.
   3. Provide fuses for equipment that is not UL or UR listed.
   4. Install intrinsically safe circuits and equipment in accordance with UL 698A.

## 1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

## 1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

## 1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. Provide control panels identified in the Contract Documents.

### 2.02 DESIGN AND PERFORMANCE CRITERIA

A. Panel dimensions:
   1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon the manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size panels:
      a. Size panels to provide space for equipment, wiring, terminations, and other items in the panel, including 20 percent of the total back panel area shall remain empty.
      b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
      c. Maximum panel depth: 32 inches, unless otherwise indicated.

B. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01850 - Design Criteria and as indicated on the Drawings.

C. Non-conditioned spaces and outdoor installations:
   1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

D. As listed below in the individual component paragraphs.
   1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

### 2.03 MANUFACTURERS (NOT USED)

### 2.04 EXISTING PRODUCTS (NOT USED)

### 2.05 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA Type 1: Steel.
      b. NEMA Type 4: Steel with gasketed door, raintight.
      c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
      d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
      e. NEMA Type 12: Steel with gasketed door, dusttight.

f. NEMA Type 7: Cast aluminum.

B. Bolting material:
1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
2. Carriage bolts for attaching end plates.
3. Other bolted joints shall have S.A.E. standard lock washers.

## 2.06 MANUFACTURED UNITS

A. Panels/enclosures:
1. Manufacturers: One of the following or equal:
a. nVent/Hoffman.
b. Rittal.
c. Saginaw Control & Engineering.
2. Panel assembly:
a. General guidelines for panel fabrication include:
1) Continuous welds ground smooth.
2) Exposed surfaces free of burrs and sharp edges.
3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

| Enclosure Height (inches) | Minimum Enclosure Steel Thickness (gauge) | Minimum Back Mounting Panel Thickness (gauge) |
|---|---|---|
| Wall-mounted up to 48 | 14 | 14 |
| Up to 57 | 12 | 12 |
| 57 to 69 | 12 | 10 |
| 69 to 82 | 12, except 10 on back | 10 |
| 82 or more | 10 | 10 |

1) Use heavier sheet metal to meet seismic requirements at the Project Site or when required due to equipment requirements.
c. For Rittal or engineer-approved equal free-standing modular enclosure, construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

| Enclosure Height (inches) | Minimum Enclosure Steel Thickness (gauge) | Minimum Back Mounting Panel Thickness (gauge) |
|---|---|---|
| Wall-mounted up to 48 | 16 | 14 |
| Up to 57 | 14 | 13 |
| 57 or more | 16 | 11 |

d. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the

same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

e. Provide stiffeners for back mounting or C folded back panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

f. Door construction:
   1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
   2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
   3) Heavy-gauge stainless steel hinges.
   4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
   5) Gasket installed to seal against roll lip on the enclosure opening.

g. Latches:
   1) For panels, provide each door with an oil tight 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
      a) Provide padlock for each enclosure with padlock provisions.
      b) Provide 2 keys per panel.
      c) All locks keyed alike.
   2) For Rittal or engineer-approved equal free-standing modular enclosure, provide each door with a 4-point latching mechanism, if available, or a 2-point latching mechanism if a 4-point is not available.
   3) For cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.

h. Panel cut-outs:
   1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
   2) Allow a minimum of 3-inch envelope around displays, controllers, and monitors.
   3) Reinforce around cut-outs with steel angles or flat bars for the following:
      a) Large panel cutouts; for example, openings for local operator interfaces.
      b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
   a. Minimum 16-gauge, Type 304 stainless steel.
   b. Captive stainless steel cover screws threaded into sealed wells.
   c. Inside finish: White polyester powder coating.
   d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
   e. NEMA Type 4X powder-coated stainless steel enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.

4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
    a. Enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
    b. Door hardware: Stainless steel.
    c. Provide factory installed rain canopy and sun shield for enclosures with operator interface panels.
    d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
    1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
    2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
    3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
    4. Control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent protection:
    1. Main overcurrent device:
        a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
            1) Door-mounted disconnect handles are not acceptable.
            2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
            3) Provide means to defeat the interlock.
            4) Lockable in the off position.
        b. Control panels supplied with 120 VAC:
            1) Provide an internal breaker with the line side terminals covered by a barrier.
            2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
            3) Provide a nameplate prominently positioned on the control panel stating “CAUTION Risk of Electric Shock - UPS equipment outputs remain energized with main disconnect in off position” for any panel containing a UPS.
    2. Selection and ratings of protective devices:
        a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
        b. Voltage rating: Not less than the voltage of the application.
        c. Select current rating and trip characteristics to be suitable for:
            1) Maximum normal operating current.

2) Inrush characteristics.
3) Coordination of the protective devices to each other and to the source breaker feeding the panel.

d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.
2) Miscellaneous, miniature, and micro fuses listed under UL 248, Part 14, that do not comply with UL 508A requirements are not acceptable.
3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.

3. Provide a separate protective device for each powered electrical device:
a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
b. Provide fuse external of the I/O card.
c. Individual discrete output:
1) Individual fuse for each PLC discrete output.
2) Size external fuse to open before any I/O-card-mounted fuses.
d. Individual discrete input:
1) Individual fuse for each PLC discrete input.
2) 1/2-amp fuse.
e. Individual analog input:
1) Individual fuse for each PLC analog input powered from the control panel.
2) 1/4-amp fuse.
f. Individual analog output:
1) Individual fuse for each PLC analog output powered from the control panel.
2) 1/4-amp fuse.
g. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.

4. Fuses for analog and discrete control loops:
a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
1) Label shall not cover or interfere with the equipment manufacturer's instructions.
b. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
c. Manufacturers: One of the following or equal:
1) Bussmann.
2) Ferraz Shawmut.
3) Littelfuse.

5. Fuse holders:
a. Modular type:
1) DIN rail mounting on 35-millimeter rail.
2) Touch-safe design: Connection terminals to be protected against accidental touch.
3) Incorporates blown-fuse indicator.

4) Plug-in style fuse terminals and fuse plugs are not acceptable.
b. Provide nameplate identifying each fuse:
1) As specified in Section 16075 - Identification for Electrical Systems.
c. Manufacturers: One of the following or equal:
1) Allen-Bradley, 1492-FB Series B.
2) Phoenix Contact, UT4-HESI Series.
6. Control circuit breakers:
a. DIN rail mounting on 35-millimeter rail.
b. Manual OPEN-CLOSE toggle switch.
c. Rated for 250 VAC.
d. Interrupting rating: 10 kA or available fault current at the line terminal, whichever is higher.
e. Current ratings: As required for the application.
f. Provide nameplate identifying each circuit breaker:
1) As specified in Section 16075 - Identification for Electrical Systems.
g. Manufacturers: One of the following or equal:
1) ABB.
2) Allen-Bradley.
3) Phoenix Contact, TMC Series.
4) Square D.
7. Electronic circuit protectors:
a. Used where a NEC Class 2 power circuit is required.
b. Confirms to NEC Class 2 according to UL 1310.
c. DIN rail mounting on 35-millimeter rail.
d. Power source:
1) Operating voltage: 24 VDC.
2) Output current ratings: As required for the application.
3) Maximum output current: 4 A.
4) Maximum nameplate rating: 100 VA.
e. LED for status indication.
f. Remote status contact.
g. When using multi-channel electronic circuit protectors, distribute devices such that a failure is limited to a single network or segment.
h. Provide nameplate identifying each circuit electronic circuit protector module:
1) As specified in Section 16075 - Identification for Electrical Systems.
i. Manufacturers: One of the following or equal:
1) Single channel:
a) Allen-Bradley, 1694 series.
b) Phoenix Contact, PTCB E1 series.
2) Multi-channel:
a) Phoenix Contact, CBMC series.
b) Puls PISA11 series.

D. Conductors and cables:
1. Power and control wiring:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 VAC type MTW.
c. Minimum sizes:
1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.

3) Control: 16 AWG.

d. Color:
1) AC power (line and load): Black.
2) AC power (neutral): White.
3) AC control: Red.
4) AC control: Orange for foreign voltages.
5) DC power and control (ungrounded): Blue.
6) DC power and control (grounded): White with Blue stripe.
7) Ground: Green.

2. Signal cables:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 VAC, PVC outer jacket.
c. Minimum size: 18 AWG paired triad.
d. Overall aluminum shield (tape).
e. Copper drain wire.
f. Color:
1) 2-conductor:
a) Positive (+): Black.
b) Negative (-): White and red.
2) 3-conductor:
a) Positive (+): Black.
b) Negative (-): Red.
c) Signal: White.
g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:
1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
2. Readily identified without twisting the conductor.

F. General wiring requirements:
1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for general purpose (no open wiring) unless otherwise specified.
2. Install components in accordance with the manufacturer's instructions included in the listing and labeling.
3. Provide a nameplate on the cover of the control panel identifying sources of power supply and foreign voltages within the control panel.
4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
5. Provide power surge protection for control panels.
6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (copper ethernet, coax, fieldbus signals) that originates from outdoor devices.
7. Provide non-metallic ducts for routing and organization of conductors and cables:
a. Provide wiring separation plan.
b. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.

c. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
    1) 120 VAC: Grey colored ducts.
    2) 24 VDC: White colored ducts.

8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
    a. Screw-on cable tie mounts.
    b. Hammer-on cable-tie mounting clips.
    c. Fingers of the nonmetallic duct.
9. Wire ties:
    a. No wire ties inside wire duct.
    b. Use Panduit cable tie installation tool, with tension control/cutoff.
    c. Verify cut ends are cut flush filed smooth after installed.
10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
11. Support panel conductors where necessary to keep them in place.
12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
    a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
14. Control panel shall be the source of power for 120 VAC devices interconnected with the control panel, including, but not limited to:
    a. Solenoid valves.
    b. Instruments both mounted in the control panel and remotely connected to the control panel.

G. Provide power circuits for Contractor- and vendor-furnished PLC cabinets in accordance with the PLC and instrument power wiring diagrams indicated on the Drawings or as specified.

H. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.

2. Enclosure temperature switch:
    a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
    b. Sensor and electronic enclosure.
    c. Accuracy: Within 2 degrees Fahrenheit.
    d. Single contact:
        1) Manufacturers: One of the following or equal:
            a) nVent/Hoffman ATEMNC.
            b) Pfannenberg FLZ.
            c) Rittal.

e. Dual contact:
1) Manufacturers: One of the following or equal:
a) nVent/Hoffman ADLTEMP.
b) Rittal.

3. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
a. Provide as indicated on the Drawings or as specified.

4. Fan ventilation:
a. Provide nVent/Hoffman or Rittal fan speed control:
1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
2) Provide finger-guard kit.
3) Filter kit with 2 spare filters for each intake fan.
4) Provide bezel and gasket kit.
5) Provide fan shroud.
6) Automatically adjust fan speed depending on remote temperature sensor input.
7) 120 VAC, 60 hertz.
8) NEMA Type 5-15R cord connections.

I. Pilot devices:
1. General:
a. Provide operator pushbuttons, switches, and pilot lights from a single manufacturer.
b. Size:
1) 30.5 millimeters.
c. Heavy duty.
d. Pushbuttons:
1) Contacts rated:
a) NEMA Type A600.
2) Furnish 1 spare normally open contact and normally closed contact with each switch.
3) Equipment shutdown (ESD): Palm or mushroom-head type with self-latching feature. ESD device will remain in the actuated position until deliberately reset.
e. Selector switches:
1) Contacts rated:
a) NEMA Type A600.
b) Knob type.
2) Furnish 1 spare normally open contact and normally closed contact with each switch.
3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot lights:
1) Type:
a) LED for interior installations.
2) Push to test.
3) Lamp color:
a) On/Running/Start: Red.
b) Off/Stop: Green.
c) Power: White.

d) Alarm: Amber.
e) Status or normal condition: White.
f) Opened: Red.
g) Closed: Green.
h) Failure: Red.

2. Indoor and outdoor areas:
   a. NEMA Type 4/13.
   b. Manufacturers: One of the following or equal:
      1) Allen-Bradley, Type 800T.
      2) General Electric, Type CR104P.
      3) IDEC, TWND Series.
      4) Schneider Electric, Class 9001, Type K.
3. Corrosive areas:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
   d. Manufacturers: One of the following or equal:
      1) Allen-Bradley, Type 800H.
      2) Cutler Hammer, Type E34.
      3) IDEC, TWND Series.
      4) Schneider Electric, Class 9001, Type SK.
4. Hazardous (classified) areas/Class I, Division 2:
   a. NEMA Type 4X.
   b. Corrosion resistant.
   c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
      1) Contacts contained within a hermetically sealed chamber:
         a) Pushbuttons.
         b) Selector switches.
         c) Push-to-test contacts on pilot lights.
      2) UL listed and labeled for Class I, Division 2 areas.
   d. Manufacturers: One of the following or equal:
      1) Allen-Bradley, Type 800H.
      2) Cutler Hammer, Type E34.

J. Potentiometer and slidewire transmitters:
   1. Provide a DC output in proportion to a potentiometer input.
   2. Potentiometer input:
      a. 100 ohms to 100 K ohms.
      b. Impedance greater or equal to 1 M ohms.
      c. Zero turn-up: 80 percent of full-scale input.
      d. Span turn-down: 80 percent of full-scale input.
   3. Field-configurable output:
      a. Voltage and current: Conventional current loops and voltage control signals.
   4. Accuracy, including linearity and hysteresis, within 0.1 percent maximum at 77 degrees Fahrenheit.
   5. Operating temperature: 32 degrees to 131 degrees Fahrenheit.
   6. Supply power: 9 to 30 VDC.

7. Manufacturers: One of the following or equal:
    a. Allen-Bradley, Type 800T-U29.
    b. Phoenix Contact, Mini Analog Pro.

K. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
    b. Adjustable span and zero.
    c. Accuracy: Within 1.0 percent of span.
    d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
2. Manufacturers: One of the following or equal:
    a. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
    b. Action Instruments, Q500 Series or Ultra SlimPak II.
    c. AGM Electronics, Model TA-4000.
    d. Moore Industries, MIT 4-Channel.
    e. Phoenix Contact, Mini Analog Pro.

L. Relays:
1. General:
    a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
    b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
    c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
2. Control:
    a. Magnetic style.
    b. For use as standard control relay for motor and starter relay logic.
    c. NEMA ratings:
        1) 300 volts.
        2) 10 amps thermal continuous test current.
        3) 60 amps make.
        4) 6 amps break.
    d. Plug-in type.
    e. LED indication for energization status.
    f. Coil voltages: As required for the application.
    g. Minimum poles: DPDT.
    h. Touch-safe design: Connection terminals to be protected against accidental touch.
    i. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
    j. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
    k. Relays with screw-type socket terminals.
    l. Provide additional relays when the following occurs:
        1) Number or type of contacts shown exceeds the contact capacity of the specified relays.
        2) Higher contact rating is required in order to interface with starter circuits or other equipment.
    m. DIN rail mounting on 35-millimeter rail.
    n. Ice-cube-type relays with retainer clips to secure relay in socket.

o. Integrated label holder for device labeling.
p. Manufacturers: One of the following or equal:
1) Allen-Bradley: Type 700 HC.
2) IDEC: R* Series (* = H, J, R, S, U).
3) Potter and Brumfield: Type KRP or KUP.
4) Square D: Type K.

3. Isolation:
a. Electromechanical style.
b. For use as an interposing relay for PLC based discrete I/O signals.
c. NEMA ratings:
1) Switching voltage: 250 volts AC/DC.
2) Limiting current: 6 amps continuous.
3) Interrupt: 1,500 volt-amperes.
d. Plug-in type.
e. LED indication for energization status.
f. Coil voltages: As required for the application.
g. Minimum poles: SPDT.
h. Touch-safe design: Connection terminals to be protected against accidental touch.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. DIN rail mounting on 35-millimeter rail.
l. Integrated label holder for device labeling.
m. Manufacturers: One of the following or equal:
1) Allen-Bradley, Type 700 HL TBR Series.
2) Eaton, XR TBR Series.
3) IDEC, RV8H Series.
4) Phoenix Contact, PLC-INTERFACE Series.

4. Latching:
a. Magnetic-latching control relays.
b. NEMA ratings:
1) 300 volts.
2) 5 amps continuous.
3) 360 volt-amperes make.
4) 320 volt-amperes break.
c. Plug-in type.
d. DIN rail mounting on 35-millimeter rail.
e. Coil voltage: As required for the application.
f. Minimum contacts: DPDT; as required for the application. Plus 1 spare contact.
g. Touch-safe design: Connection terminals to be protected against accidental touch.
h. Clear cover for visual inspection.
i. Provide retainer clip to secure relay in socket.
j. Manufacturers: One of the following or equal:
1) IDEC, RR2KP Series.
2) Square D, 8501, Type K.

5. Time delay:
a. Provide time-delay relays to control contact transition time.

b. Contact rating:
    1) 240 volts.
    2) 10 amps continuous.
    3) 3,600 volt-amperes make.
    4) 360 volt-amperes break.
c. Coil voltage: As required for the application.
d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
    1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
e. Minimum contacts: DPDT.
f. Units include adjustable dial with graduated scale covering the time range in each case.
g. Minimum timing range: 0.1 second to 10 minutes, or as required for the application.
h. Manufacturers: One of the following or equal:
    1) Allen-Bradley, Type 700-HR.
    2) IDEC, RTE Series.
    3) Tyco Electronics, Agastat 7000 Series (pneumatic).

M. Terminal blocks:
1. DIN rail mounting on 35-millimeter rail.
2. Rated for 15 amps at 600 volts.
3. Screw terminal type.
4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for terminals for conductors.
6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
7. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
8. Disconnect-type field signal conductor terminals with socket/screw for testing.
9. Identify terminals suitable for use with more than 1 conductor.
10. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
11. Manufacturers: One of the following or equal:
    a. Allen-Bradley, 1492 Series.
    b. Phoenix Contact, UT4 Series.
    c. Phoenix Contact UT6 Series, Allen-Bradley Bulletin 1492 Double-level, Weidmuller Klippon W-series, multi-level (screw terminal) terminal blocks.

N. DIN rail grounding:
1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
    a. Mount to DIN rail via grounding foot with mounting screw.
    b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.

c. Not be used for grounding signal cable shields.
2. Screw terminal type.
3. DIN rail mounting on 35-millimeter rail.
4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for terminals for conductors.
6. Terminals: Plainly identified to correspond with markings on the diagrams:
   a. Permanent machine-printed terminal identification.
7. Manufacturers: One of the following or equal:
   a. Allen-Bradley, 1492-JG Series.
   b. Phoenix Contact, USKLG Series.

O. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
2. Type:
   a. Wide slot.
   b. Narrow slot.
   c. Round hole.
3. Manufacturers: One of the following or equal:
   a. ABB.
   b. Iboco.
   c. Panduit.
   d. Phoenix Contact.

P. DIN rail:
1. Perforated steel.
2. 35-mm width.
3. 15-mm deep.
4. Provide 2-inch offset using one of the following:
   a. Offset brackets.
   b. Preformed standoff DIN Rail Channel.

Q. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
   a. Provide SPD for panel 120 VAC power entrances:
      1) Non-faulting and non-interrupting design.
      2) Provide line to neutral and neutral to ground surge protection.
   b. Provide surge protection at secondary of main circuit breaker:
      1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
      2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
   c. DIN rail mounting.
   d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
      1) Gastight connections.
      2) Visual status indication of MOV status on the input and output circuits.
      3) Dry contact rated for remote status indication.

e. Approvals:
    1) Tested in accordance with IEC 61643-11.
    2) Tested in accordance with UL 1283.
    3) Tested in accordance with UL 1449.
    4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1, Category C Area.
f. Manufacturers: One of the following or equal:
    1) ASCO, Model 277.
    2) Phoenix Contact, Type SFP Filter.
    3) Rockwell, 4983-DC series.
    4) Sola HD, STFE Elite series.

2. 24 VDC control panel power SPD:
    a. Provide SPD for 24 VDC power circuits.
    b. Provide surge protection at DC power supply output.
    c. DIN rail mounting.
    d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
        1) Optical status indicator.
        2) Dry contact rated for remote status indication.
    e. Approvals:
        1) Tested in accordance with IEC 61643-11.
    f. Manufacturers: One of the following or equal:
        1) Field instruments that require auxiliary power:
            a) Emerson, Model 265 (SLAC) series.
            b) Phoenix Contact, Plugtrab PLT--SEC-T3-24-FM-UT.
        2) Loop powered field instruments:
            a) Emerson/Edco, Model SS65-036-2.

3. Panel mounted control, signal, and data line SPD:
    a. General:
        1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
        2) Approvals:
            a) Tested in accordance with IEC 61643-21.
            b) Tested in accordance with UL 497B.
        3) SPD shall consist of 2 parts:
            a) Base module:
                (1) DIN rail mounting.
                    (a) Grounded to DIN rail via mounting rail foot.
            b) Plug protection module:
                (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
        4) Provide indirect shield ground style SPD unless otherwise noted.
        5) Provide ability to locally identify and indicate SPD health.
        6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
        7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
        8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.

b. Manufacturers: One of the following or equal:
    1) Dehn, Blitzductor XTU Series.
    2) Phoenix Contact, Plugtrab PT-IQ Series.

4. Copper Ethernet SPD:
    a. Protects network equipment from lightning or other surge events.
    b. Suitable for Gigabit networks.
    c. Shielded RJ-45 ports.
    d. In accordance with PoE standards IEEE 802.3af and 802.3at.
    e. Nominal discharge surge current: 10 kA.
    f. Approvals:
        1) Tested in accordance with IEC 61643-21.
        2) Tested in accordance with UL 497B.
    g. Manufacturers: One of the following or equal:
        1) Citel, MJ8-C6A.
        2) Eaton/MTL, ZoneBarrier High Energy Ethernet.
        3) Phoenix Contact, DT-LAN-CAT6+.
        4) Weidmuller, VDATA CAT6.
5. Field device mounted SPD:
    a. Conduit entry mounting.
        1) Provide parallel or through wiring configurations as required by the application.
            a) Use parallel wiring configuration if there is an available cable gland at the device.
            b) Use through wiring configuration if there is no available cable gland at the device.
        2) Provide screw connections compatible with field device.
    b. NEMA 4X stainless steel material housing.
    c. Approvals:
        1) Tested in accordance with IEC 61643-21.
    d. 4-wire field device:
        1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
            a) Maximum continuous voltage:
                (1) DC:
                    (a) Signal: 32 VDC.
                    (b) Power supply: 255 VDC.
                (2) AC:
                    (a) Signal: 22.6 VAC.
                    (b) Power supply: 255 VAC.
        2) Manufacturers: The following; Engineer knows of no equal:
            a) Endress+Hauser, HAW569-CB2C.
    e. 2-wire or 3-wire field device:
        1) Module shall provide protection for the signal cable, communication bus or data line.
        2) Manufacturers: One of the following or equal:
            a) Eaton/MTL, TP Series.
            b) Endress+Hauser, HAW569 Series.
            c) Phoenix Contact, Surgetrab S-PT Series.

R. Power supplies:
   1. Configure power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
   2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
   3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
   4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
      a. Provide automatic switchover upon module failure.
      b. Alarm contacts monitored by the PLC.
   5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
   6. Sized to provide 40-percent excess rated capacity.
   7. UL 508 listed to allow full-rated output without de-rating.
   8. Provide fuse or short-circuit protection.
   9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
   10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
   11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
   12. Touch-safe design: Connection terminals to be protected against accidental touch.
   13. DIN rail mounting on 35-millimeter rail:
      a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
   14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
   15. Manufacturers: One of the following or equal:
      a. Fully redundant:
         1) IDEC, PS5R Series:
         2) Phoenix Contact, Quint Power Supply with SFB technology.
            a) Phoenix Contact, Quint.
         3) PULS.
         4) Sola.
      b. Redundancy module:
         1) Phoenix Contact, O-ring redundancy module.

S. Intrinsic safety barriers:
   1. Transformer isolated barrier:
      a. Containing a transformer to provide complete:
         1) Isolation between the safe and hazardous areas for loop-powered devices.
         2) 3-way isolation between the safe area, hazardous area, and power supply powered devices.
      b. Resistor for current limitation.

c. Fuses for short-circuit protection.
d. Provide barriers with pluggable connectors that are coded for easy replacement.
e. Transmission error shall be less than or equal to 0.1 percent of full-scale.
f. DIN rail mounting on 35-millimeter rail.
g. Approvals:
1) FM.
2) UL 913.

2. Types:
a. Switch isolators:
1) Designed and approved for use with discrete inputs.
2) Supply power: 20 to 30 VDC.
3) Output to track input.
4) LED in the cover to indicate the status of the input.
5) Selector switch to change the logic of the input.
6) Input: Dry contact.
7) Output: SPDT relay.
b. Transmitter and converters for use with 4- to 20-mA signals without Hart® communications capability:
1) Designed and approved for use with 4- to 20-mA analog signals.
2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
3) Supply voltage: 20 to 30 VDC.
c. Transmitter and converters for use with 4- to 20-mA signals with Hart® communications capability:
1) Designed and approved for use with 4- to 20-mA analog signals.
2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
3) Transfer digital signals from the hazardous area to the safe area.
4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
5) Supply voltage: 20 to 30 VDC.

3. Manufacturers: One of the following or equal:
a. Pepperl + Fuchs.
b. Phoenix Contact, MACX Series.

T. Limit switches:
1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating temperature range: 0 degrees to 230 degrees Fahrenheit).
9. Manufacturers: One of the following or equal:
a. ABB.
b. Allen-Bradley, 802 Series.
c. Eaton, E47, E49, E50.

d. Honeywell, HDLS Series.
e. Omron, D4 Series.

U. Proximity switches:
1. Power supply: 24 VDC supply voltage.
2. 1 normally open and normally closed contacts.
3. LED optical sensing, polar-retro.
4. Distance: 6 meters (19.8 feet).
5. Manufacturers: The following or equal:
a. Banner T30 or equal.

V. Current switches:
1. Power supply: 120 VAC supply voltage.
2. 1 normally open and normally closed contacts.
3. Adjustable current setting.
4. Manufacturers: One of the following or equal:
a. Phoenix Contact, EMD Series.
b. Zelio®, RM35.

W. Panel mount quick connector:
1. Keyed insertion plug.
2. Threaded cap to protect connection when not in use.
3. Material: Stainless steel.
4. Pre-wired pigtails.
5. Indoor/outdoor:
a. Rating: Meets or exceeds panel rating.
b. Manufacturers: One of the following or equal:
1) Amphenol.
2) Sealcon.
6. Hazardous (classified) areas:
a. UL listed and labeled for area as indicated on the Drawings.
b. Manufacturers: The following or equal:
1) Amphenol HDE Series.

## 2.07 ACCESSORIES

A. Provide panels with an inside protective pocket to hold the panel drawings.
1. Ship panels with 1 copy of accepted Shop Drawings, including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

B. Provide floor stands or legs with a minimum height of 12 inches where needed or as indicated on the Drawings.

C. Provide a folding shelf for enclosures that contain programmable controllers. Shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

D. Provide nameplate to each panel as indicated on the Drawings:
1. As specified in Section 16075 - Identification for Electrical Systems on internal and external instruments and devices.

2. With the following markings that is plainly visible after installation:
    a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
    b. Supply voltage, phase, frequency, and full-load current.
    c. Power source or circuit ID.
    d. Short-circuit current rating of the panel based on one of the following:
        1) A listed and labeled assembly.
        2) Established utilizing an approved method.

E. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
    a. Covered or guarded.
    b. Provide On-Off door-activated switches where indicated on the Drawings.
    c. 120-volt, single-phase, 15-amp style plug.
    d. Provide 4,000 K, 900 lumens LED fixture.
        1) Provide additional fixtures for every 36 inches of width.

F. Receptacles:
1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 120-volt, single-phase, 15-amp style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amps.

G. Grounding:
1. Provide the following:
    a. Grounding strap between enclosure doors and the enclosure.
    b. Equipment grounding conductor terminals.
    c. Provide equipment grounding busbar with lugs for connection of equipment grounding wires.
    d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND", the letter "G", or the color green.
3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at the control panel.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Unless otherwise noted, connect exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
    a. Control panel ground lugs and ground bar shall be copper mechanical or compression connection type. Aluminum connectors or lugs are not acceptable for use with copper conductors.

H. Sunshades:
   1. Where indicated, provide panel-mounted sunshades for outdoor installations.
   2. Provide thermally insulated standoff.
   3. Provide deburred cutouts for access to exterior panel accessories.
   4. Material of sunshade and mounting hardware shall match enclosure.

## 2.08 FINISHES

A. Finishes:
   1. Metallic (non-stainless):
      a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
      b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied according to the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
      c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
      d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
   2. Stainless steel:
      a. Stainless enclosures shall be provided with a No. 4 brushed finish, not painted.

B. Colors:
   1. Exterior color of panels mounted indoors shall be the manufacturer's standard light gray.
   2. Exterior of panels mounted outdoors shall be the manufacturer's standard white.
   3. Panel interiors shall be the manufacturer's standard white.

# PART 3 EXECUTION

## 3.01 PREPARATION

A. Equipment support and anchoring to structures:
   1. As specified in Section 01850 - Design Criteria, including, but not limited to:
      a. Anchor bolt layout.
      b. Equipment templates.
      c. Anchor installation.

## 3.02 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel: Anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details.

C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.

D. Provide concrete housekeeping pads for freestanding enclosures.
   1. Refer to the structural typical details.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor-mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. Holes for field conduits, etc., shall be cut in the field. No additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.

H. Protect wiring from sharp edges and corners.

I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the loop drawings prepared by the Contractor.

J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.

K. Side panels:
   1. Side panels shall be kept free of control equipment and devices. Any deviation must be sent to the Engineer in writing asking for a deviation.

L. Doors:
   1. Provide snake-skin cable management sleeve or spiral wire-wrap on wires where they pass from the interior of the cabinet past the door hinge to door-mounted devices.

## 3.03 TESTING

A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION

**SECTION 17950**

**COMMISSIONING FOR INSTRUMENTATION AND CONTROLS**

**TABLE OF CONTENTS**

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

### 1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. Telecommunications Industry Association (TIA).

### 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. 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.
   2. Loop validation tests - Signals are tested from the field device to the PLC.
   3. Permanent link: Fixed portion of cabling installed between an equipment outlet and its immediate distributor or between 2 distributors.
   4. Platform testing: Testing of the PLC and SCADA/HMI at the manufacturer's shop to demonstrate the program's functionality based upon specified and designed control requirements.

### 1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. General:
   1. Reference additional detailed test Submittal scheduling and prerequisite requirements as specified in the sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Overall test plan:
   1. Develop the PCIS system test Submittals in consultation and cooperation with applicable Subcontractors.
   2. Develop and submit an overall testing plan for the PCIS. Overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
   3. Describe the test phases as they apply specifically to this Project and each process system.
   4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
   5. Provide examples of proposed forms and checklists.

D. Test procedures:
   1. Provide a statement of test objectives for each test.
   2. Prepare specific procedures for each process system.
   3. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
   4. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
   5. Describe the expected role of the Engineer, as well as any requirements for assistance from the Owner's staff.
   6. Provide the forms and checklists to be used.

E. Test forms:
   1. Submit completed calibration forms, test forms, and checklists.
      a. Test forms shall include the detailed test procedures or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
      b. Every page of each test form shall include Project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
      c. Sample test forms at the end of this Section show the minimum required content:
         1) Sample test forms have not been customized for this Project.
         2) Develop and submit test forms customized for the Project and meeting the specified test and Submittal requirements.

F. Testing binders:
   1. Sub-system to be tested: Provide and submit a test binder containing test procedures and individual forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance, headings and all other information known before the test.
   3. Include applicable test plan information, as well as a list of test prerequisites, test personnel, and equipment.
   4. Include or list reference material and provide separately at the time of the test.
   5. Record test results and verify that all test requirements and conditions have been met.

G. Furnish Commissioning Submittals listed below, as specified in this Section, and Section 01756 - Commissioning:
   1. Manufacturer's representative qualifications.
   2. Owner Training.

H. Test reports:
   1. At the conclusion of each test, submit a complete test report, including test results and certifications.
   2. Include completed test binders, forms, and checklists.

3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

I. Furnish 4 CD/DVD copies of the following:
   1. Application software:
      a. Finalized fully annotated copy of programmed PLC logic in its native format.
      b. Cross-referenced index of PLC registers or points.

## 1.05 QUALITY ASSURANCE

A. Test personnel:
   1. Furnish qualified technical personnel to perform calibration, testing, and verification. Test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

## 3.01 EXAMINATION (NOT USED)

## 3.02 INSTALLATION

A. Installation supervision:
   1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

## 3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Testing and training phase:

   1. Installation testing:
      a. Loop check:
         1) Performed by the Contractor.
         2) Cabling installed, terminated, and labeled.
         3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
         4) Complete loop check form for each device.
         5) Submit loop check test results before proceeding to the next step.
      b. Loop validation tests:
         1) Performed by the Contractor, ICSC, and the manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
         2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
            a) PLC may or may not be connected to the network.

3) Engineer approval of the loop validation test Submittal is required before proceeding to CEET.
4) Network operations testing:
    a) Performed by the Contractor and programmer working together.
    b) General requirements:
        (1) Network performance is monitored and measured using non-intrusive test equipment and procedures in accordance with the referenced standards:
            (a) Profibus networks.
        (2) Modifications required as a result of network operations validation and shall be in accordance with the applicable standards from Profibus organization, North America, PTO.
    c) Online evaluation:
        (1) Confirm specified agent devices appear on the live list.
        (2) Evaluate data traffic between controller and each agent to confirm proper agent configuration and performance.
        (3) Inspect waveform capture for evidence of excessive noise.
        (4) Evaluate and report any failed or questionable network tests.
        (5) Evaluate and report network error codes and related symptoms.
    d) Network operations validation and testing report:
        (1) Prepare a report that documents the results of the qualification and testing activities, including, but not limited to, the following:
            (a) Document the installed condition of the network and provide baseline values for future network maintenance and testing activities.
            (b) Executive summary for each network, including the following:
                - Inspection and test results for each network.
                - Calculated network parameters.
                - Recommendations.
                - Description of test procedures and required test equipment.
                - Network agency specifications.
            (c) Manufacturer's specifications and guidelines:
                - Include applicable manufacturer's specifications and guidelines.
                - May supersede the specifications of the applicable governing body for the associated network but at a minimum must meet the governing body's requirements.
    e) Submit final report of the industrial network testing to the Engineer upon successful completion of the testing.
5) Engineer approval of the industrial network testing Submittals is required before proceeding to CEET.

c. Complete End-to-End Testing (CEET):
1) Performed by the Contractor and programmer working together, with assistance from the Owner or the inspection staff, as needed:
    a) Participants need to be dedicated full-time to CEET.

b) Programmer will provide staff to verify input signals at, and create output signals from, an HMI or engineering workstation.
c) Contractor will be responsible for creating field signals and verifying proper operation of final control elements.

2) Prerequisites:
a) CEET cannot begin until the successful completion of the preceding tests:
(1) Calibration.
(2) Loop check.
(3) Loop validation tests.
(4) Copper Ethernet cable acceptance testing.
(5) Industrial network testing.

3) Testing description:
a) This testing is to ensure I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. Outputs will be energized for a duration long enough to verify proper operation of the final control element.
c) SCADA screens:
(1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
(2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
(3) Retest any loop following any necessary corrections.

4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system:
a) Use actual process inputs wherever available.
b) Issue commands from the HMI/SCADA system and verify proper responses of field devices:
(1) Test SCADA system inputs from field device to SCADA system operator workstations:
(a) Track responses through trend charts in the HMI/SCADA system.
(2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
c) Observe and record responses at intermediate devices.

5) Discrete device testing:
a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
(1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
(2) Exercise starters, relay contacts, switch contacts, and observe proper operation.

(3) Calibrate and test instruments supplying discrete inputs and observe proper operation.

b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
   (1) Stroke valves through outputs from the HMI/SCADA system and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
   (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
   (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.

6) Analog device testing:
   a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
   b) Apply provisional settings on controllers and alarm setpoints.
7) Analog input:
   a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system:
      (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
8) Analog output:
   a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system:
      (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc., to confirm the proper operation of the device for the supplied analog signal.
      (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
9) Submit completed test forms:
   a) Discrete instrument input devices:
      (1) Switch setting, contact action, and dead band.
      (2) Valve position switches:
         (a) Response in the PLC as the valve is stroked from the PLC.
         (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
      (3) Operator interface switches (control stations and other pilot devices) and associated response.
      (4) Starter and drive auxiliary device contact response.
      (5) Response of all other discrete inputs to the PLC.
      (6) Test equipment used and associated serial numbers.

b) Discrete output devices:
(1) Observed response of field device to the discrete output from the PLC.
(2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
(3) Test equipment used and associated serial numbers.
c) Analog input devices:
(1) Calibration range.
(2) Calibration data: Input, output, and error at each test value.
(3) Analog input associated PLC register address.
(4) Value in PLC register at each test point.
(5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
(6) Test equipment used and associated serial numbers.
d) Analog output devices:
(1) Calibration range.
(2) Test value at each test point.
(3) Analog output associated PLC register address.
(4) Control variable value at field device at each test point.
(5) Physical device response at each test point:
(a) Response to be actual valve position, or motor speed, etc.
(6) Test equipment used and associated serial numbers.

10) Failure testing:
a) Demonstrate how the system reacts and recovers from abnormal conditions, including, but not limited to:
(1) Equipment failure.
(2) Communications sub-system error.
(3) Power failure.
(4) Process equipment failure.
(5) High system loading conditions.

11) Engineer approval of the CEET Submittals is required before proceeding to Functional Testing.

2. Functional Testing:
a. General:
1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
2) Performed by the Contractor and programmer working together, with assistance from the Owner or the inspection staff, as needed.
3) Additional tests are specified in other instrumentation and control Sections.
4) Follow approved detailed test procedures and check lists for Functional test activities.

b. Control logic operational validation:
1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, control panels (including vendor control panels), control circuits, control stations, monitored/controlled equipment, and final control elements.

2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, electrical Specifications, and mechanical equipment Specifications.
3) Test in detail on a function-by-function and sentence-by-sentence basis.
4) Thoroughly test hardware and software functions, including hardwired and software control circuit interlocks and alarms.
5) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify logic and control is achieved.
6) Control logic validation tests to include, but not be limited to, a repeat of control logic tests from the FAT, modified and expanded to include field instruments, control panels, circuits, and equipment.

c. Loop tuning:
1) Optimally tune electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.
a) As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
4) Functional validation sheets:
a) Document each Functional test on an approved test form.
b) Document loop tuning with a report for each loop, including 2-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by the Contractor and Engineer.
c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
(1) Loop number and P&ID number.
(2) Control strategy, or reference to specification tested.
(3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test

form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
(1) Specification page and paragraph of function demonstrated.
(2) Description of function and/or text from specification.
(3) Test procedures: Use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.

5) Functional certification:
   a) Including test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that Functional test requirements have been satisfied.

## 3.04 SCHEDULES

A. Example test forms:
   1. Attached at the end of this Section. They may be used as a starting point for the development of project-specific test forms for this Project.
   2. Not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

# ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

## FACTORY ACCEPTANCE TEST - CONTROL PANELS

**1. GENERAL INSPECTION**

**A. Structural Inspection**

- ☐ Verify lifting lugs installed.
- ☐ Verity enclosure has lock and lock is functional.
- ☐ Confirm that seismic bracing components are provided in accordance with manufacturer's installation instructions.

**B. Exterior Inspection**

- ☐ Cabinet exterior is clean, scratch, and dent free.
- ☐ Inspect externally for corrosion and damage.
- ☐ Verify enclosure door opens and closes easily.
- ☐ Verify enclosure has a 3-point latch.
- ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet).
- ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.).
- ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant).

**Nameplates**

- ☐ Cabinet has identification nameplate.
- ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract.
- ☐ Cabinet has a nameplate that includes the following:
  - ☐ Power source(s).
  - ☐ Integrator's logo.
  - ☐ Circuit ID(s).
  - ☐ Short Circuit KAIC ratings.
- ☐ If labels are screwed to door, silicone was utilized to cover screw holes. (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)

**Door Devices**

- ☐ All devices penetrating the outside of panel have gaskets, silicone or both.
- ☐ All door devices are installed (HMIs, Pilot Devices, etc.).
- ☐ Door mounted equipment is mounted straight and square.
- ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened.
- ☐ NEMA classification has not been violated due to penetrations.
- ☐ Door mounted equipment has the same NEMA rating as the panel.
- ☐ All door mounted equipment installed at the correct height.
- ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner).
- ☐ Doors with multiple penetrations have adequate bracing (if needed).
- ☐ Visually check condition of indicators, controllers, and annunciators.
- ☐ Check that pilot lights illuminate correctly.
- ☐ Check the Push-To-Test function.
- ☐ Ensure correct pilot light color.

**Peripheral Devices**

- ☐ Horn/Beacon is installed (where required).
- ☐ Silence and Reset pushbutton.

| | | | |
|---|---|---|---|
| PROJECT NAME: | _____ | TEST DATE: | _____ |
| FACILITY NAME: | _____ | TESTED BY: | _____ |
| PROCESS AREA: | _____ | COMPANY: | _____ |
| NETWORK ID: | _____ | PAGE: | _____ |
| WITNESSED BY: | _____ | SIGNATURE: | _____ |

| | FACTORY ACCEPTANCE TEST - CONTROL PANELS | |
|---|---|---|

**1. GENERAL INSPECTION (continued)**

**C. Interior Inspection**

- ☐ Cabinet is cleaned of marks and dirt.
- ☐ Inspect internally for corrosion and damage.
- ☐ Back panel is clean of marks and dirt.
- ☐ Interior of panel vacuumed and shall be free of all debris.
- ☐ Check that the panel roof is clean and clear of foreign materials.
- ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.
- ☐ If internal light door limit switch is provided, ensure the light automatically turns “on” when the doors are open.
- ☐ Check that a document pocket has been provided.
- ☐ Intrusion alarms (where required).

**Interior Labeling**

- ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.
- ☐ Verify that door mounted components are mounted square and symmetrical.
- ☐ Verify that nameplates are straight, legible, and spelled correctly.
- ☐ All terminal blocks are identified/labeled with permanent labels, including tight end blocks and caps.
- ☐ All wiring shrink labeled and or phased correctly to the specifications.
- ☐ All wire labels shrunk completely rotated and aligned alike for easy identification.
- ☐ All fuses and circuit breakers are labeled with ID and current rating.
- ☐ System Integrator’s label or labels installed on door.
- ☐ Panel manufacturer model/serial number tag is present.
- ☐ All required safety/warning tags installed and straight.
- ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight. (The UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.)

**Wireways**

- ☐ Plastic wire way covers installed properly.
- ☐ Plastic wireways have no sharp edges.
- ☐ No wire ties inside the wireways.
- ☐ No sharp edges on wire ties.
- ☐ Separation: White duct is used for DC voltages; Gray duct is used for AC voltages.
- ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.

| | | | |
|---|---|---|---|
| PROJECT NAME: | _____ | TEST DATE: | _____ |
| FACILITY NAME: | _____ | TESTED BY: | _____ |
| PROCESS AREA: | _____ | COMPANY: | _____ |
| NETWORK ID: | _____ | PAGE: | _____ |
| WITNESSED BY: | _____ | SIGNATURE: | _____ |

| | FACTORY ACCEPTANCE TEST - CONTROL PANELS | |
|---|---|---|

**1. GENERAL INSPECTION (continued)**

**C. Interior Inspection (continued)**

**Wiring**

- ☐ Visually check terminals and condition of internal wirings.
- ☐ Verify that the control panel has been assembled and wired as designed.
- ☐ Verify that all components are operational and perform the functions intended.
- ☐ Verify that all components are sized appropriately for the application.
- ☐ Verify that equipment control circuits function as intended.
- ☐ Back of door wiring is labeled and neatly formed.
- ☐ Back panel to door wiring has sufficient bending radius with spiral wrap.
- ☐ Wire connection has been verified wired to correct points within the panel.
- ☐ Individual wires have been given a pull test to verify a good terminal connection.
- ☐ Wire and cable minimum bending radius have not been violated.
- ☐ All equipment installed straight and square to back panel.
- ☐ Wire colors are correct:
  - ☐ Black and White > AC hot and neutral, respectively.
  - ☐ Red > AC control signals.
  - ☐ Blue > DC power and control.
  - ☐ White w/Blue stripes > DC ground.
  - ☐ Yellow > Foreign voltages (those still present when panel power is disconnected).
  - ☐ Green > AC equipment ground.
  - ☐ Black > TSP (+).
  - ☐ White > TSP(-).
- ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields).
- ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself.
- ☐ Discrete inputs are separately fused or protected by a circuit breaker on a “per loop” basis.
- ☐ Intrinsic Safety Wiring.
  - ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring.
- ☐ Verify all spare terminals are installed according to the percentage listed in the specifications.

**Grounding**

- ☐ Equipped with “Blackburn” or other grounding type lug.
- ☐ Lug is securely fastened to the panel structure.
- ☐ Verify grounding bar is installed.
- ☐ Verify isolated ground bar is installed.

| | | | |
|---|---|---|---|
| PROJECT NAME: | _____ | TEST DATE: | _____ |
| FACILITY NAME: | _____ | TESTED BY: | _____ |
| PROCESS AREA: | _____ | COMPANY: | _____ |
| NETWORK ID: | _____ | PAGE: | _____ |
| WITNESSED BY: | _____ | SIGNATURE: | _____ |

| | FACTORY ACCEPTANCE TEST - CONTROL PANELS | |
|---|---|---|

**2. POWER TEST**

**A. AC Power**

- ☐ AC power is routed correctly within the panel and is isolated from DC and network wiring.
- ☐ All fuses are installed and sized properly.
- ☐ All breakers are installed and sized properly.
- ☐ 24 VDC Power Supplies are functional.
- ☐ 24 VDC Power fail contacts are functional.
- ☐ 24 VDC power supplies are redundant and have diode modules enabling the hot swap-over between supplies.
  - ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.
- ☐ Dedicated receptacle is wired to receive a dedicated AC supply.
- ☐ Verify continuity for all DC commons, ground and AC neutrals.
- ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage.
- ☐ Close the CP main circuit breaker(s).
- ☐ Verify that voltages at subsequent circuit breakers are correct.
- ☐ Close circuit breakers.
- ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct.
- ☐ Turn on power supplies if they are not already on.
- ☐ Verify that voltages at distribution terminals are correct.
- ☐ Energize any remaining hardware such as the PLC.

**B. Uninterruptible Power Supply (UPS)**

- ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.
- ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).
- ☐ Test all UPS alarms (on inverter, failure, battery failure etc.).
- ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.

**3. CONTROLS & AUXILIARY DEVICES TEST**

- ☐ Verify all interposing and auxiliary relays are functioning.
- ☐ Verify panel lights are functioning.

**Ventilation and Heating**

- ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.
- ☐ Verify components are installed in the correct orientation for proper air flow.

**4. HARDWIRED INTERLOCK AND SAFETY TEST**

- ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.
- ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.

| | | | |
|---|---|---|---|
| PROJECT NAME: | _____ | TEST DATE: | _____ |
| FACILITY NAME: | _____ | TESTED BY: | _____ |
| PROCESS AREA: | _____ | COMPANY: | _____ |
| NETWORK ID: | _____ | PAGE: | _____ |
| WITNESSED BY: | _____ | SIGNATURE: | _____ |

| | FACTORY ACCEPTANCE TEST - CONTROL PANELS | |
|---|---|---|

**5. PLC TEST**

**A. Components**

☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.

☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.

☐ TVSS is installed across the main incoming 120 VAC.

**PLC and PLC Rack**

- ☐ Verify all cards are securely seated.
- ☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations.

**B. PLC I/O Test**

☐ Furnish **I/O test forms** and test all the listed input and output points as follows:

- ☐ Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software.
- ☐ Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting.
- ☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.
- ☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.

**C. Redundant Controllers (where required) Test**

☐ Remove Communication cable from primary PLC to verify switching to backup PLC.

☐ Remove Communication cable from backup PLC to verify switching back to primary PLC.

☐ Remove Power cable from primary PLC to verify switching to backup PLC.

☐ Remove Power cable from backup PLC to verify switching back to primary PLC.

**D. PLC Control Logic Verification**

☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.

- ☐
- ☐
- ☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal.
- ☐ For example, when starters and drives are not provided as part of the Contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.

| | | | |
|---|---|---|---|
| PROJECT NAME: | _____ | TEST DATE: | _____ |
| FACILITY NAME: | _____ | TESTED BY: | _____ |
| PROCESS AREA: | _____ | COMPANY: | _____ |
| NETWORK ID: | _____ | PAGE: | _____ |
| WITNESSED BY: | _____ | SIGNATURE: | _____ |

**5. PLC TEST (continued)**

**D. PLC Control Logic Verification (continued)**

**Typical Fault Logic**

- ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.
- ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.

**Typical Fail to Start Logic**

- ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

**6. HMI OR OIT TEST**

**HMI/OIT Functionality**

- ☐ Communication with PLC.
- ☐ Screen Layouts.
- ☐ Screen Navigation.
- ☐ Set Point Entry.
- ☐ Animation.
- ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention).
- ☐ Alarms.
- ☐ Acknowledge and Reset.
- ☐ Security/Access Levels/Passwords.

**7. NETWORK COMMUNICATION TEST**

**A. Network Components**

- ☐ Fiber optic cabling terminates in a patch panel.
- ☐ Media converters are installed and functional.
- ☐ Terminating resistors have been installed for trunk/tap topologies or where required.
- ☐ Wire and cable bending limitations have not been violated.

**B. Networking Functions**

- ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams.
- ☐ Verify network traffic rate and error margin is acceptable.

| | | | |
|---|---|---|---|
| PROJECT NAME: | | TEST DATE: | |
| FACILITY NAME: | | TESTED BY: | |
| PROCESS AREA: | | COMPANY: | |
| NETWORK ID: | | PAGE: | |
| WITNESSED BY: | | SIGNATURE: | |

| | FACTORY ACCEPTANCE TEST - CONTROL PANELS | |
|---|---|---|

**8. FAT DOCUMENTATION AND RECORD**

**Panel Documentation**

- ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- ☐ Panel schematic and interconnection drawings.
- ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- ☐ I/O list test forms of the process area to be tested.
- ☐ FAT procedure of the process area to be tested.
- ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- ☐ Hard copy of the PLC application program of the process area to be tested.
- ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested.

**9. FAT TOOLS AND SOFTWARE**

- ☐ Simulation software if required.
- ☐ Digital volt meter Fluke 87.
- ☐ Process meter Fluke 787.
- ☐ Laptop computer with PLC application program.
- ☐ Temporary SCADA computer with HMI software and applicable graphic screens.
- ☐ Jumper wires.

| | | | |
|---|---|---|---|
| PROJECT NAME: | | TEST DATE: | |
| FACILITY NAME: | | TESTED BY: | |
| PROCESS AREA: | | COMPANY: | |
| NETWORK ID: | | PAGE: | |
| WITNESSED BY: | SIGNATURE: | | |

## ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

| | INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION | |
|---|---|---|

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

| | ☐ No | ☐ Yes |
|---|---|---|
| INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? | | |

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

# ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

| | SWITCHES<br>INSTALLATION AND CALIBRATION CHECKLIST | |
|---|---|---|

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

| | ☐ No | ☐ Yes |
|---|---|---|
| INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? | | |

**FIELD CALIBRATION CHECK**

| CONTACT NO. | FUNCTION | FOR SIGNAL | CONTACT IS TO | AT SPECIFIED VALUE FOR | | ACTUAL TRIP POINT WAS | |
|---|---|---|---|---|---|---|---|
| 1 | ☐ ALARM | ☐ INCR | ☐ OPEN | SET PT = | | SET PT = | |
| | ☐ S/D PERM | ☐ DECR | ☐ CLOSE | RESET = | | RESET = | |
| 2 | ☐ ALARM | ☐ INCR | ☐ OPEN | SET PT = | | SET PT = | |
| | ☐ S/D PERM | ☐ DECR | ☐ CLOSE | RESET = | | RESET = | |
| 3 | ☐ ALARM | ☐ INCR | ☐ OPEN | SET PT = | | SET PT = | |
| | ☐ S/D PERM | ☐ DECR | ☐ CLOSE | RESET = | | RESET = | |
| 4 | ☐ ALARM | ☐ INCR | ☐ OPEN | SET PT = | | SET PT = | |
| | ☐ S/D PERM | ☐ DECR | ☐ CLOSE | RESET = | | RESET = | |

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

| | | |
|---|---|---|
| | **SWITCHES**<br>**INSTALLATION AND CALIBRATION CHECKLIST** | |

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

# ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST

| | TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST | |
|---|---|---|

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

**BENCH CALIBRATION CHECK**

INPUT RANGE = _____ OUTPUT RANGE = _____

HEAD CORRECTION = _____ ☐ LINEAR

CALIBRATED SPAN = _____ ☐ SQUARE ROOT

| % CALIB SPAN | DESIRED VALUE | ACTUAL VALUE | EXPECTED VALUE | ACTUAL VALUE |
|---|---|---|---|---|
| 0 | | | | |
| 50 | | | | |
| 100 | | | | |

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

**FIELD CALIBRATION CHECK**

INPUT RANGE = _____ OUTPUT RANGE = _____

| % CALIB SPAN | DESIRED VALUE | ACTUAL VALUE | EXPECTED VALUE | ACTUAL VALUE |
|---|---|---|---|---|
| 0 | | | | |
| 50 | | | | |
| 100 | | | | |

| | TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST | |
|---|---|---|

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _____ SPAN

| CONTROLLER SETTINGS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SETTING** | **GAIN** | **PB** | **RESET (INTEGRAL)** | **DERIV. (RATE)** | **HIGH LIMIT** | **LOW LIMIT** | **ELEV. ZERO** | **ZERO SUPP** |
| PRE-TUNE | | | | | | | | |
| POST-TUNE | | | | | | | | |

| PRE-TUNE SETTINGS | | | | | |
|---|---|---|---|---|---|
| | **GAIN** | **PB** | **RESET (REPEAT/MIN)** | **RESET (MIN/REPEAT)** | **DERIVATION (MINUTES)** |
| FLOW | 1.0 | 100 | 10 | 0.1 | N/A |
| LEVEL | 1.0 | 100 | MIN. | MAX. | N/A |
| PRESSURE | 2.0 | 50 | 2.0 | 0.5 | N/A |
| TEMP. | 4.0 | 25 | 0.1 | 10 | OFF |

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

# ATTACHMENT E - ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST

| | **ANALYZERS**<br>**INSTALLATION AND CALIBRATION CHECKLIST** | |
|---|---|---|

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

# ATTACHMENT F - CONTROL VALVES
# INSTALLATION AND CALIBRATION CHECKLIST

| | CONTROL VALVES<br>INSTALLATION AND CALIBRATION CHECKLIST | |
|---|---|---|

☐ No ☐ Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

☐ VALVE TAG NO. _____ SERIAL NO. _____

☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____

☐ SOLENOID TAG NO. _____ SERIAL NO. _____

☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____

☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

| TRANSDUCER CHECK | | | | | |
|---|---|---|---|---|---|
| INPUT RANGE = | | | OUTPUT RANGE = | | |
| CALIBRATED SPAN = | | | CALIBRATED SPAN = | | |
| **BENCH** | | | | | |
| **SPAN** | **DESIRED** | **ACTUAL** | **SPAN** | **EXPECTED** | **ACTUAL** |
| 0% | | | 0% | | |
| 50% | | | 50% | | |
| 100% | | | 100% | | |
| **FIELD** | | | | | |
| **SPAN** | **DESIRED** | **ACTUAL** | **SPAN** | **EXPECTED** | **ACTUAL** |
| 0% | | | 0% | | |
| 50% | | | 50% | | |
| 100% | | | 100% | | |

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____

- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

| | CONTROL VALVES<br>INSTALLATION AND CALIBRATION CHECKLIST | |
|---|---|---|

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

| VALVE CHECK | | | |
|---|---|---|---|
| FLOW CHECK | ☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT | | |
| SAFETY CHECK | ON LOSS OF AIR VALVE FAILS<br>☐ OPEN ☐ CLOSE | ON LOSS OF POWER SOLENOID FAILS<br>☐ TO VENT ☐ TO VALVE | |
| TRAVEL CHECK | FULL OPEN AT _____ PSI | FULL CLOSED AT _____ PSI | MEASURED TRAVEL _____ INCHES |
| SEATING CHECK | ☐ ON BENCH<br>☐ IN-LINE | RESULTS | ACTUATOR BENCH SET |
| **POSITIONER CHECK** | | | |
| VALVE FULL OPEN AT _____ PSI TO POSITIONER _____ | | | |
| VALVE FULL CLOSED AT _____ PSI TO POSITIONER _____ | | | |
| **VOLUME BOOSTER CHECK** | | | |
| BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS) | | | |

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____